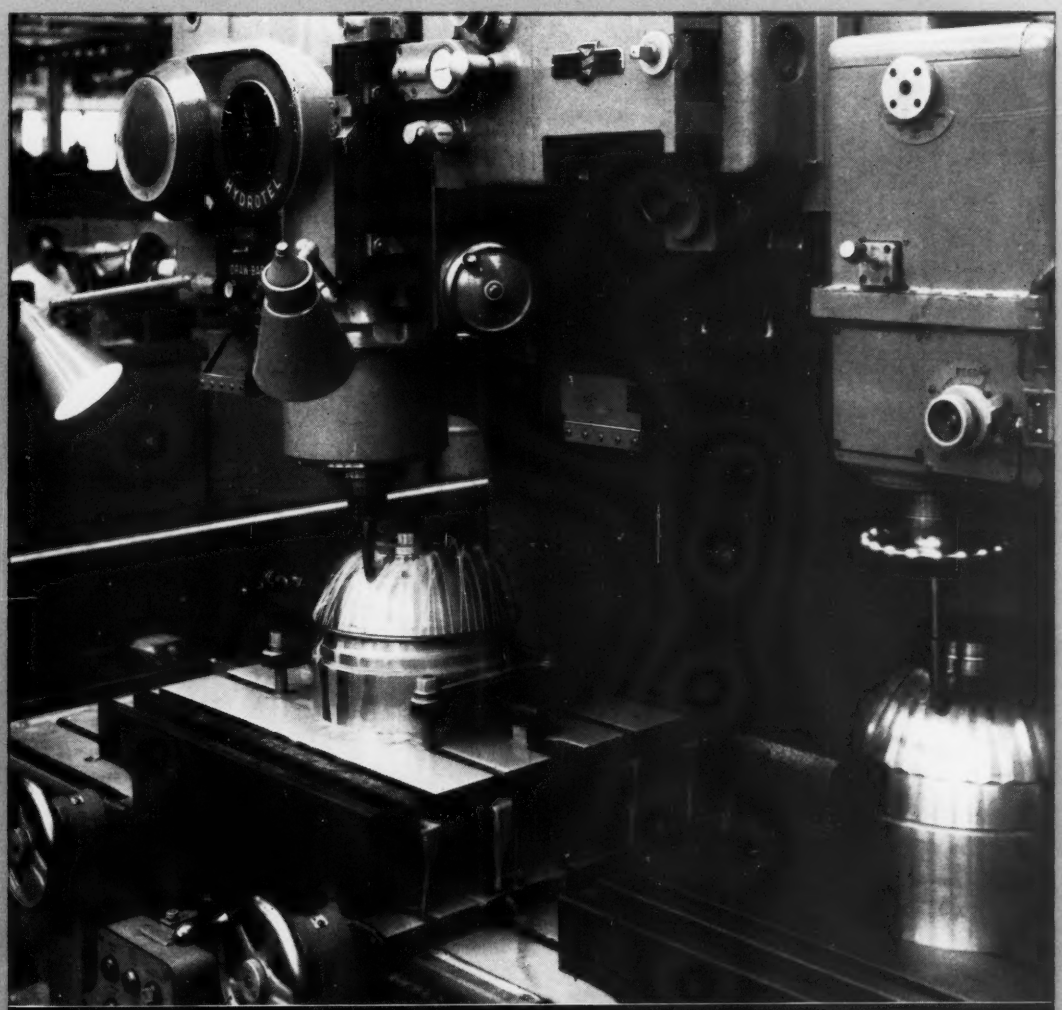
Vol. 16, No. 9 September, 1960

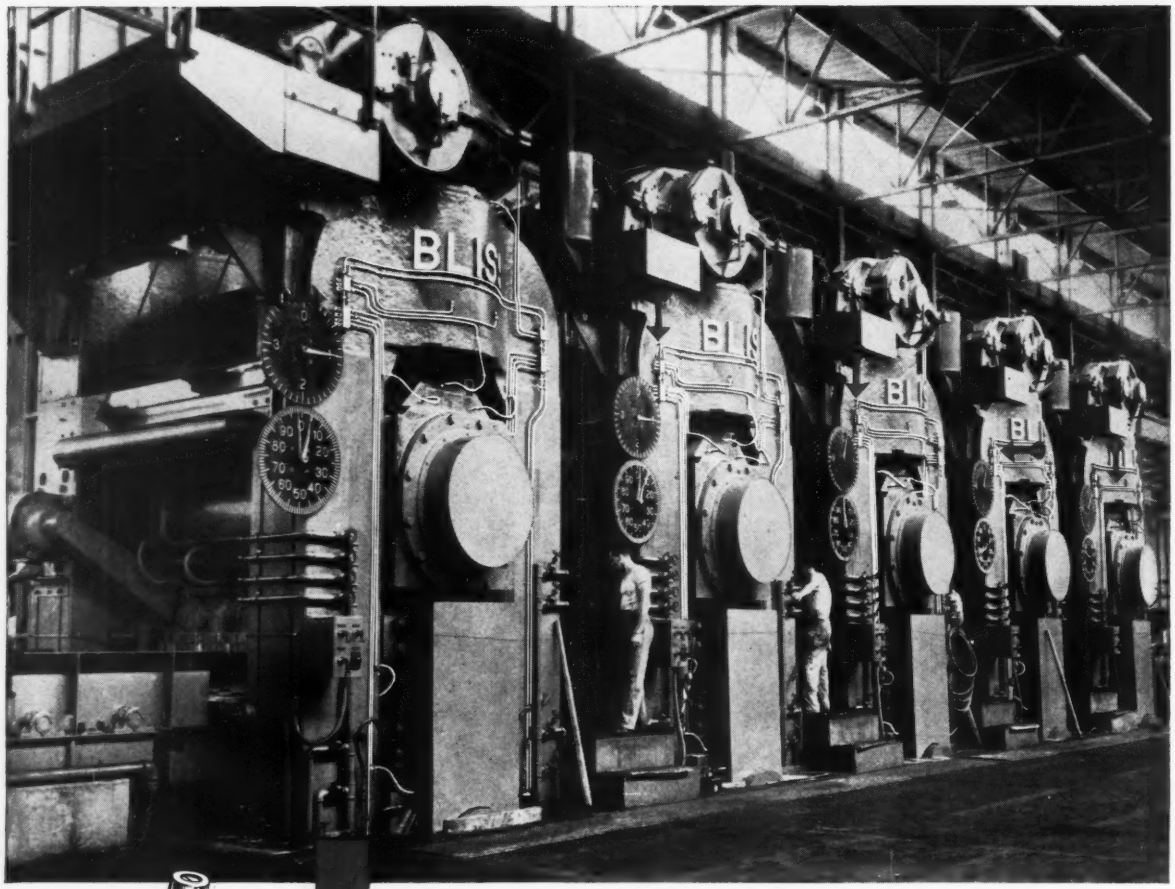
LUBRICATION ENGINEERING

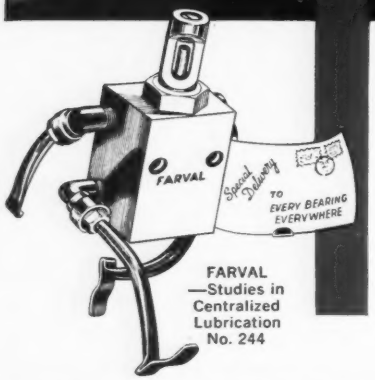
DESIGN RESEARCH APPLICATION EDUCATION MAINTENANCE



SEE PAGE 400 FOR "PRECISE DUPLICATION BY HYDRAULIC TRACING"

JOURNAL OF THE AMERICAN SOCIETY OF LUBRICATION ENGINEERS





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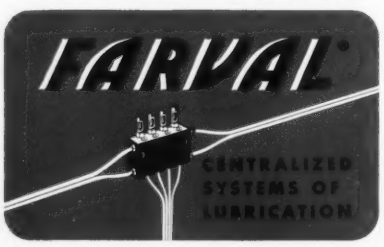

Volume 16, No. 9
September, 1960

Lubrication Engineering

DESIGN RESEARCH APPLICATION EDUCATION MAINTENANCE

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NEW *EMRALON*® TFE COATINGS SOLVE HEAT SENSITIVE APPLICATIONS

Acheson's resin-bonded tetrafluoroethylene (TFE) surface coatings are finding ready acceptance among design engineers. Where previous limitations of pure TFE prevented its application on heat sensitive substrates, because of its 700° F. sintering temperature, 'EMRALON' coatings are being successfully used on rubber, light metals, woods, and plastic. One such impressive case history is outlined here.

'EMRALON' coating is shown being spray-applied on woven belting with conventional equipment.

OVER $15,000.00 ANNUAL SAVINGS PROJECTED BY PROMINENT TIRE MANUFACTURER

Dunlop Tire and Rubber Corporation, Buffalo, N. Y., estimates this considerable savings in down-time costs alone on the basis of nearly nine months production use of an 'EMRALON'-coated belt conveyor. The particular belt involved is thirty feet long. Its importance in this company's tire production is emphasized by the fact that it is located at the point of a previous bottleneck. Rubber strips, conveyed from a series of masticating mills to an extruding press, formerly became stuck to the belting of this short-run conveyor immediately above the final masticator. The reason: the temperature of the rubber is elevated — through friction of the masticating process — to between 150° F. and 300° F. at this point. Belts had to be replaced anywhere from once every several hours to every six weeks. It was not unusual to have two or three stoppages every shift. The result: with the supply of rubber temporarily cut off, the entire department shut down. Costs ran $5.00 a minute, and with these work stoppages averaging 20 minutes each, the accumulated expense became prohibitive. Since April, 1959, the new belt has been in constant operation at this critical point in the masticating line.

To date it has not been removed from the mill . . . ample proof of the extraordinary non-stick, adhesion and flexing qualities of its 'EMRALON' coating!

The woven conveyor belt is a product of Globe Woven Belting Company, Buffalo, N.Y. Application of Acheson's 'EMRALON' to their belting was the outcome of a continuing research program headed by Globe Research Manager, Fred Kohlhagen. It is applied by standard commercial spray equipment to a film thickness of 0.7 mils and then oven-cured at a temperature of 300° F.

According to Mr. Kohlhagen, "This example will be only one of many success stories told about this coating. 'EMRALON'-coated belting can be used anywhere a slick, non-corrosive belting is needed. Those in the baking, canning, food processing, food packaging, and rubber fields should find immediate use for it." We might add that there are many other industries finding it advantageous to use 'EMRALON' . . . yours quite possibly is one of them. Why not write today for further information?

'EMRALON' — coated conveyor belt carrying hot rubber through masticating mill.

'dag' is a trademark registered in the U. S. Patent office by Acheson Industries, Inc.

'EMRALON' ADVANTAGES PROVED IN MANY LIGHT-LOAD USES

The growing list of production applications for the new Acheson 'EMRALON' surface coatings, is convincing proof of their versatility. That film pack, office machine, and lock mechanisms; rubber molds and oil seals; bakery dough handling equipment and countless other light load, solid-film lubrication problems have successfully been answered, is now a matter of record.

With 'EMRALON' 310* — colloidal TFE in a phenolic resin solution — a one-hour cure at 300° F. is all that is necessary. And, for substrates even more sensitive to heat, 'EMRALON' 320** colloidal TFE in a thermo-plastic resin carrier — is available. Both provide excellent adhesion, low coefficient of friction, flexibility, toughness, and corrosion resistance. Applied by conventional paint spray equipment, they allow easy production line conversion to 'EMRALON' solid-film lubricants.

'EMRALON' coatings represent the latest in a long line of widely accepted Acheson products, one of which may offer a ready-made answer to your particular lubrication problem. We welcome the opportunity to be of service. Send for your copy of our Products List which outlines the full line of Acheson Dispersions. Address Dept. LE-90.

*'EMRALON' 310 is manufactured under exclusive license from E. I. duPont deNemours & Company (Inc.) under U. S. Patent 2,825,706. Not licensed for use or for sale for use in providing electrical insulation.

**'EMRALON' 320 — patent applied for.

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September, 1960

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LUBRICATION IN THE NEWS

The Society will not be responsible for the accuracy of statements made in this column. Any reference to proprietary products does not imply an endorsement of such products by the Society.

AIR FORCE AND NAVY SPONSOR LUBRICANTS CONFERENCE

More than 300 participants are expected to attend the unclassified Air Force-Navy-Industry Propulsion Systems Lubricants Conference to be held in San Antonio, Texas on November 15 through 17, 1960. The meeting will be sponsored jointly by Air Research and Development Command's Wright Air Development Division and Southwest Research Institute. Headquarters will be in the Hilton Hotel.

The three-day meeting will deal with such topics as "Missile and Space Vehicle Lubrication Requirements," "Lubrication with Cryogenic Fluids," "Lubrication with Liquid Metals and Nonmetals," "New Development in Greases and Fluids," and "High Performance Aircraft Engine Lubrication." (Source: Southwest Research Institute)

ASA PUBLISHES AMERICAN STANDARD IDENTIFICATION CODE FOR BALL AND ROLLER BEARINGS

Developed under the sectional committee method of ASA procedures, the new American Standard Identification Code for Ball and Roller Bearings, B54.1-1960, sponsored by the Anti-Friction Bearing Manufacturers Association, has been approved and published by the American Standard Association. Seventeen manufacturer and user organizations from industry and government were represented on the B54 committee which drew up this standard.

Specifically, B54.1 distinguishes, as far as possible, each bearing on the basis of dimensional and functional interchangeability. Ball and roller bearings are distinguished by means of types and principal dimensions: bore, outside diameter, and width. The code also permits indexing of bearing characteristics conditioned by installation requirements. It provides a universal language to facilitate communications between the user and the manufacturers. It is also meant to simplify the handling by the user's personnel of identical bearings made by different manufacturers whose various identification numbers may be difficult to interpret.

According to J. M. Bryant, chairman of the Committee on Bearing Numbers of the Anti-Friction Bearing Manufacturers Association, which sponsored the new standard, this code is also of great international significance since it has been used as the basis for an international standard being developed through the International Organization for Standardization (ISO).

American Standard Identification Code for Ball and Roller Bearings, B54.1-1960, is available at $4.00 per copy from the American Standards Association, Dept. PR164, 10 East 40th Street, New York 16, New York. (Source: American Standards Association)

IRON AND STEEL CONVENTION FEATURES LUBRICATION SESSION

New lubricants and lubrication techniques will be subjects for a technical session at the 1960 Iron and Steel Convention and Exposition to be held in Cleveland Auditorium, September 27 through 30. The event will include three technical papers on the subject, as well as exhibits by many leading manufacturers in the field.

New bulk grease handling systems will be one of the topics reviewed by representatives of U.S. Steel Corporation, Revere Copper and Brass, Inc., and Morgan Construction Company.

The session will include the following: "Test Stand Evaluation of Oil Film Roll Neck Bearings" by Norman A. Wilson, Manager of Research, and Samuel S. Ricley, Chief Engineer, Morgoil Bearing Department, Morgan Construction Company, Worcester, Mass.; "New Methods for Handling Grease" by Charles A. Bailey, Lubrication Engineer, National Tube Division, and Donald R. McCaa, Product Manager, Standard Products Department, American Bridge Division, United States Steel Corporation, Pittsburgh, Pa.; "Oil Mist Lubrication on Antifriction Back-up Roll Bearings" by C. W. Southering, Chief Engineer, Dallas Division, Revere Copper and Brass, Inc., Chicago, Illinois. (Source: Association of Iron and Steel Engineers)

C. M. FLOYD PRESENTED ASME SPEAKERS AWARD

ASLE member C. M. Floyd, Humble senior research chemical engineer, has received the Speakers Award presented annually by the Oil, Gas and Power Division of American Society

C. M. FLOYD

of Mechanical Engineers. Entitled "A Field Study of Gas Engine Lubricants," the paper that won this national award is based on ten years of research on gas engine lubrication that led to the development of a superior new lubricant. The experiments were conducted on compressors in the refinery and in field installations. (Source: Humble Oil and Refining Co.)

NEW STANDARD METAL-ORGANIC MATERIALS FOR ANALYSIS OF PETROLEUM PRODUCTS

A set of 24 standard metal-organic samples, suitable for spectrographic and chemical analysis of petroleum products, are now available from the National Bureau of Standards. These crystalline, oil-soluble samples—are

(Continued on page 387)

Better Greases Through BAROID RESEARCH

BARAGEL 24* provides greater stability in greases made from non-petroleum oils

BARAGEL 24, a non-soap grease-gelling agent, gives greater stability to greases made from such non-petroleum oils as polyalkylene glycols, di-2-ethylhexyl sebacate, di-2-ethylhexyl adipate and castor oil. The development of BARAGEL 24 is another result of Baroid Chemicals' research.

Greases compounded with BARAGEL 24 are subjected to the most rigid testing. One of these tests measures grease penetration over the range of unworked to 10,000 strokes. In non-petroleum based oils, BARAGEL 24 produces greases that are exceptionally stable to working in the ASTM grease worker. These greases show minimum breakdown under the most rigorous operating conditions.

BARAGEL 24 is a reaction product of organic ammonium halides and refined sodium montmorillonite. BARAGEL 24 is a member of the BARAGEL-BENTONE* family of products which has been used so successfully in greases, plastics, paints, inks and other fields.

*Trademark of National Lead Company for an organic ammonium montmorillonite

6074

BAROID CHEMICALS, INC.

A SUBSIDIARY OF
NATIONAL LEAD COMPANY

1809 SOUTH COAST BUILDING
HOUSTON 2, TEXAS

LUBE IN THE NEWS

(Continued from page 385)

distributed with a certificate of analysis plus directions for preparing a solution of the substance. They can be employed as controls in the determination of metals in crank-case oils, gasolines and other petroleum products. Further information may be obtained by writing to Standard Sample Clerk, National Bureau of Standards, Washington 25, D.C. (Source: National Bureau of Standards)

BROADER INTERNATIONAL USE OF ASTM STANDARDS URGED

At the 63rd ASTM Annual Meeting, F. L. LaQue, retiring president, pointed out that technical assistance to underdeveloped countries, in the form of ASTM standards, would provide information not available in any other form and would aid in putting international trade in materials on a sound basis.

Said Mr. LaQue, "In the field of materials, the 14,359 pages in the ten volumes of ASTM standards comprise the greatest concentration of immediately and practically usable information that it would be possible to furnish anyone needing such data . . . In most cases, no further work or search for data should be required to characterize a material needed for some specific purpose, whether it be concrete for a wall, steel for a bridge, or fuel for an engine." (Source: American Society of Testing Materials)

NATIONAL LUBRICATING GREASE INSTITUTE HOLDS 1960 ANNUAL MEETING IN CHICAGO

NLGI's 28th Annual Meeting will be held at the Edgewater Beach Hotel in Chicago on October 30-November 1. The symposiums and panels will highlight a line-up of speakers with papers of interest to the entire lubrication industry.

Shown below are some tentative titles of talks to be given before NLGI:

"Selling the Lubricating Grease Market Why Wire Rope Lubricants Are Special Compounds"

"New Grease Plant Layout"

"What's Ahead in Farm Machinery Lubrication"

"New Developments in High Temperature Grease"

"Aero Space Grease Requirement Trends"

"Lubrication of Nuclear Power Plants"

"Centralized Lubricating Systems"

"A Rapid Method for Predicting the Flow Properties of Grease"

"The Permeability of Lubricating Grease"

"Structural Changes and Phase Transitions in Lithium Grease

"Electron Microscope Examination of Thin Film Sections of Lubricating Grease"

"A Rheological Equation for Greases"

(Source: National Lubricating Grease Institute)

HIGH TEMPERATURE LUBRICANT REPORTS RELEASED TO INDUSTRY

Two research reports on high temperature lubricants and related materials, prepared for the Air Force, have been released to science and industry through the Office of Technical Services, Business and Defense Services Administration, U.S. Department of Commerce. They are:

Organo-Metallic and Organo-Metalloidal High-Temperature Lubricants and Related Materials—Part 4. H. Gilman and R. D. Gorsich, Iowa State College, for Wright Air Development Center, U.S. Air Force. May 1957. 63 pages. (Order PB 131176 from OTS, U.S. Department of Commerce, Washington 25, D. C., $1.75) The synthesis and preliminary thermal screening for 36 compounds is described. This experiment was conducted to explore the possible application of new organometallic and organo-metalloidal substances as potential high temperature lubricants and hydraulic fluids. The *meta*-biphenylyl group seemed to be equally as important as the *ortho*-biphenylyl group in having desirable physical characteristics. Some syntheses have previously been excluded because of steric hindrance. The authors feel that the methyldibenzylsilylmethyl group should be added to other promising groups, since it is particularly effective when combined with one of the new cyclic compounds. A table outlining the preliminary screening of 36 compounds for thermal stability is included in the report.

High-Temperature Evaluation Procedures for Lubricants—Part 1: Design Development and Instrumentation of a 1000F Oxidation Corrosion Bath and 400F and 700F Viscosity Baths. V. A. Lauer and D. C. Trop, Materials Laboratory, Wright Air Development Center, U.S. Air Force. Aug. 1959. 23 pages. (Order PB 161506 from OTS, U.S. Department of Commerce, Washington 25, D. C., 75 cents.) An aluminum block bath for use in oxidation corrosion tests at temperatures up to 1000F is described. The report also reviews two high temperature viscosity baths capable of maintaining temperatures of 400F and 700F respectively. All three baths are designed to develop lubricants and hydraulic fluids for high temperature service. (Source: U.S. Department of Commerce)

INDUSTRY NOTES

A new branch office and warehouse in Atlanta, Georgia has been established by Lincoln Engineering Company, St. Louis, Mo., manufacturer of lubrication equipment and air compressors for automotive, industrial and agricultural use and a line of ignition system testing equipment.

In addition to warehousing for Lincoln products, the new branch will provide service facilities for the Southeastern states of Georgia, Florida, North and South Carolina, Tennessee, Mississippi, Virginia and part of Louisiana.

General Electric has started construction of a new plant for the manufacture of basic silicone intermediate chemicals. The new plant, costing nearly $3 million, will replace smaller existing facilities which will be converted to serve other manufacturing needs at the Company's Silicone Products Department in Waterford, New York, and is expected to go into operation by late 1961.

Installation of a new $1 million piercing mill has been completed for the No. 3 Tube Mill at The Timken Roller Bearing Company's Gambrinus steel mill near Canton, Ohio. It replaces a 36-inch piercing mill which is to be reconditioned for installation and use in the Company's new No. 4 Tube Mill being constructed at the Gambrinus plant.

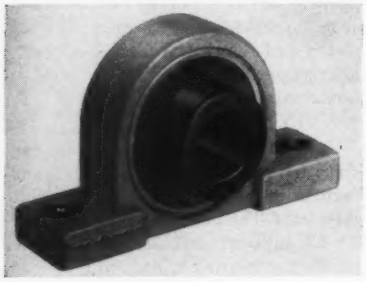
Battenfeld Grease and Oil Corp. announces the completion of an extensive addition to their lubricating grease Control and Research Laboratory in Compton, Calif. The floor space occupied by this segment of the corporation has recently been more than doubled. A number of new testing facilities have been added, including an apparent viscosity (minus 65°F) cabinet, pressure bleed and evaporation cells, plus extreme pressure and stability testing machines.

NEW PRODUCTS

NEW, NARROW WIDTH PILLOW BLOCK BEARINGS AVAILABLE

A compact line of pillow block bearings has been announced by the Hoover Ball and Bearing Company. Designated as the EDX Series, these bearings utilize housings of ductile material and are designed for light and medium duty service.

Improved retention of lubricant and exclusion of dirt results from the adoption of an improved lip type seal. Constructed of a rubber impregnated fabric between metal shields, the seals are said to maintain positive contact with the inner bearing ring at all times, regardless of shaft misalignment. The manufacturer states that factory applied lubricant lasts for the life of the bearing.



The new pillow block bearings, and the companion flange bearings, utilize an eccentric locking collar to secure the inner bearing ring to the shaft. These bearings are available in a wide range of shaft sizes from ½ to 1-3/16 inches.

Circle No. 1 on Reader Service Card

ZERO ADJUSTABLE BELLOWS COUPLING ANNOUNCED

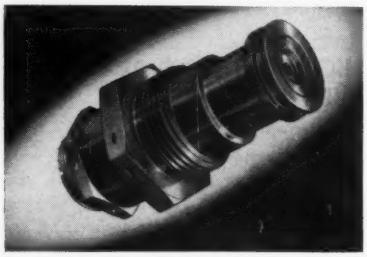
PIC Design Corporation announces a new patented zero adjustable Bellows Coupling (Type T9) which allows precision adjustment on sensitive shafts of Servo Motors, Resolvers and Synchros. It also is designed for 360° continual rotation and adjustment.

The range of adaptability is for four (4) basic shaft sizes ⅛ to ⅛, 3/16 to 3/16, ¼ to ¼ and .1200 to ⅛ and can be applied on pin and clamp type hubs.

Circle No. 6 on Reader Service Card

NEW AIR DRYING SOLID FILM LUBRICANT OFFERED

SURF-KOTE A-1290, a new type air drying solid film lubricant containing molybdenum disulfide, has been developed by Hohman Plating and Mfg. Co., Dayton, Ohio.



With application by spraying, dipping or brushing, air drying SURF-KOTE A-1290 is designed to provide a hard and durable solid film lubricant on most types of metal surfaces, and to retain a low coefficient of friction over a wide range of pressures, temperatures and surface speeds preventing galling, seizing, fretting corrosion, cold welding and similar friction problems.

Circle No. 3 on Reader Service Card

NEW CARTRIDGE FLOW REGULATOR DEVELOPED

A new cartridge flow regulator has been announced by Fluid Regulators Corporation of Painesville, Ohio.

The new regulator is designed to maintain constant flow to the system when the pump output or the upstream or downstream pressures vary.

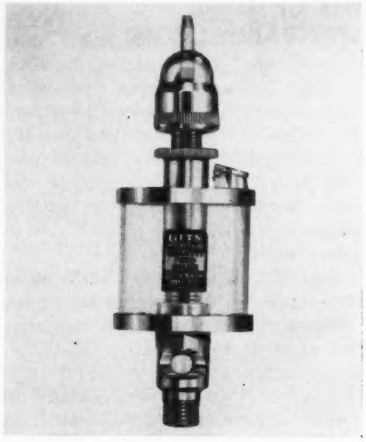
Used in a single body or a multi-valve manifold, the valve is available in a wide range of 0.1 gpm to 6.5 gpm flows. While the regulated flow is factory set, the regulator features an external adjusting screw that permits field adjustments of +10% for flows 0.1 to 1.5 gpm and +5% for flows 1.5 to 6.5 gpm.

The regulator is built for 0 to 2,000 psi operating pressure and has a pressure drop of 25 psi at high flows and 50 psi at low flows.

Circle No. 4 on Reader Service Card

LOW-COST SIGHT GRAVITY-FEED OILER ANNOUNCED

This low-cost Sight Gravity-Feed Oiler (Style EVO) has just been announced by Gits Bros. Mfg. Co., Chicago. Gits points out that the precision design features engineered into this oiler achieve accurate control of lubrication by an easy Needle Valve Adjustment. And the flow rate is locked by a knurled ring nut, once the rate has been established and adjusted.



The Needle Valve Adjustment is not disturbed by the new, easy-action Toggle Lever Shut-Off. Steady, uninterrupted metering of oil is assured by adequate venting. And a quick, convenient check of the oil delivery rate is permitted by a Sight Feed Window. Providing an instantly visible oil supply, the Gits Style EVO Oiler is available in both Glass and Unbreakable Plastic reservoirs.

Circle No. 5 on Reader Service Card

IMPROVED TEFLON FOR GASKET APPLICATIONS AVAILABLE

Teflon sheet, manufactured by an orienting process is produced and distributed by Cadillac Plastic and Chemical Company of Detroit. The Teflon sheet, known as Cadco Teflon, undergoes an orienting process which is said to reduce both initial deformation and time creep. The smoother surface produced by the orienting process is also claimed to help gasket users achieve better seals at lower bolting loads.

Circle No. 2 on Reader Service Card

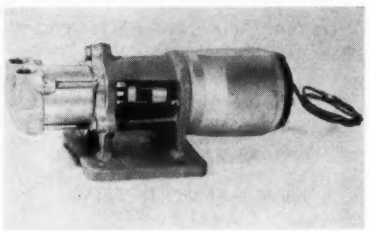
(Continued on page 389)

NEW PRODUCTS

(Continued from page 388)

NEW PUMP-MOTOR COMBINATION AVAILABLE

The Tuthill Pump Company, announced the addition of the new "Series T" pump-motor combination to its line. The new combination was developed to be run from an ordinary



12 volt DC battery. A .07 hp series wound DC motor, rated for 2300 rpm, is combined with a special Tuthill pump with a capacity of 25 gph at 60 psi. The two are connected by a bracket and coupling developed to provide proper alignment in order to obtain minimum power consumption.

Additional models in the Series T with different capacities and for various fluids may be supplied upon request.

Circle No. 7 on Reader Service Card

MULTIPLE SELECTOR VALVE FOR HYDRAULIC CIRCUITS MANUFACTURED

A new six-position, manually operated multiple selector valve for hydraulic circuits has been released by Sarasota Precision Products, Inc.

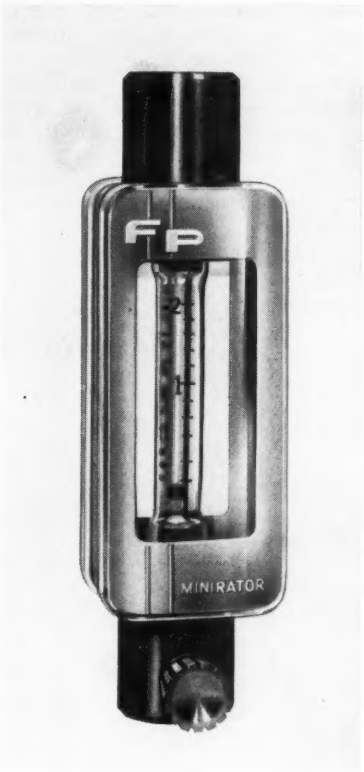
Featuring a spherical rotor design which permits the selection of flow from any one of six sources, or directs one flow to any one of six circuits, the valve is compact, and weighs only 1 lb. 8 oz. Standard valves are available with ⅛" NPTF and ¼" SAE ports. Units with special porting are also available on special order.

Built for 0 to 6000 psi operating pressure and 10,000 psi proof pressure, the valve is said to have a rated flow capacity of 0.5 GPM. It is used in machine tool, test stand, and other small high pressure circuits where positive sealing at 0-6000 psi, and low turning torque are required.

Circle No. 8 on Reader Service Card

COMPACT METER FOR LOW FLOW APPLICATIONS INTRODUCED

An inexpensive, miniature flowmeter tradenamed the MINIRATOR, which has been designed for the measurement of low flow rates of either liquids or gases, has been introduced by Fischer and Porter Company, Warminster, Pa. The features of the MINIRATOR are designed to provide



readability and accuracy. The tube of the MINIRATOR is of the "snap-in" type, permitting an easy change in range, without the use of tools. The tube floats between the end fittings and O-ring seals and is free from pipe line vibrations and misalignment stresses. End fittings can be rotated through a full 360° for ease in mounting and the meter is designed so that it may be surface or flush mounted on a panel or installed in-line.

Circle No. 9 on Reader Service Card

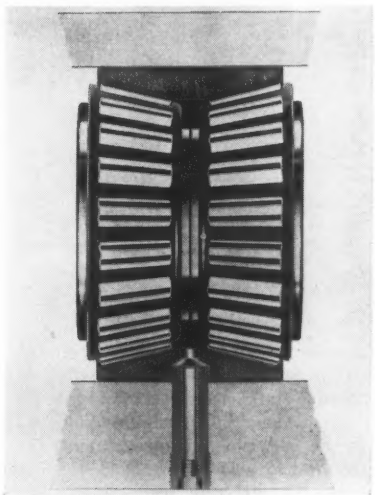
A NEW DRY FILM LUBRICANT RELEASED FOR INDUSTRIAL MARKET

For use in areas where "wet" lubrication had previously been impossible, for reasons of contamination, dust, dirt, lint, etc., MOLUB-ALLOY No. 369 DRY LUBRICANT is offered to create a protective plating of MOLUB-ALLOY self-lubricating solids in 90 seconds, leaving the lubricated surface dry. MOLUB-ALLOY No. 369 DRY LUBRICANT reportedly will withstand extreme cold and operates up to 1800°F.

Circle No. 10 on Reader Service Card

PIN-TYPE BEARINGS ADAPTED FOR MACHINE TOOLS

Designed to be dimensionally interchangeable with conventional Timken double cup bearings, The Timken Roller Bearing Company's new Pin-type double cup bearing offers advantages to machine builders in bearing applications where there is an inherent tendency for the outer race or cup to creep or turn in the housing; where experience indicates that a cup locking device is desirable.



A hollow pin, located in the housing, fits into the large counter sunk hole in the cup O.D. with ample clearance. Axial float, normally required as a result of shaft or housing expansion, is not restricted, though the pin prevents the cup from turning in the housing. Positive bearing lubrication is assured by introducing lubricant through the hollow pin, direct to the center of the bearing.

Additional engineering assistance and data may be obtained.

Circle No. 11 on Reader Service Card

(Continued on page 390)

NEW PRODUCTS

(Continued from page 389)

NEW FILTER HOUSING FEATURES SIMPLE STRAIGHT-THRU DESIGN

Special features of a new filter housing by Micro Metallic Division of PALL Corporation, include a straight-thru design, allowing the bowl to be removed from the pipe line without disturbing the pipe connections. The container design permits fabrication in a wide variety of materials with maximum cleaning ease and accessibility to all fluid passageways.

The housing is generally furnished in type 304 stainless steel, or, on special order, in an alloy to match the porous stainless steel standard elements. Also, the housings can be designed to withstand up to 10,000 psi; 125 or 300 psig is standard.

Circle No. 12 on Reader Service Card

NUGENT OFFERS STEAM TURBINE LUBRICATING OIL FILTERING SYSTEMS

A new packaged Lubricating Oil Filtering System for use with steam turbine installations is now available from Wm. W. Nugent and Co., Inc. Capacities range from 40 to over 2000 U. S. GPH.

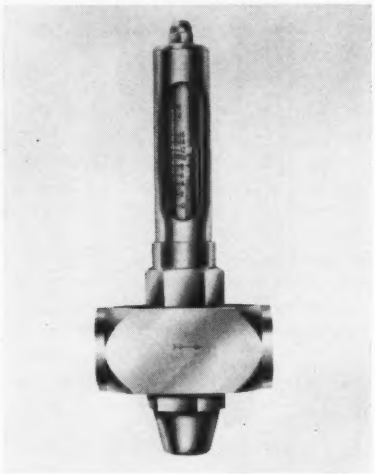
The system is said to incorporate automatic control and indicating accessories to report malfunctions to a distant control station, requiring only periodic maintenance.

Circle No. 13 on Reader Service Card

NEW ARMORED PURGE METER LINE ANNOUNCED

Wallace and Tiernan Incorporated, Belleville, N. J., announces a new line of Armored Purge Meters to supplement its recently announced range of Glass Tube Purge Meters. These meters are designed to withstand pressures to 1500 psi, and temperatures to 400°F. They have a water capacity from 1.6 to 100 gph, and an air capacity from 7.5 to 420 scfh. All piping connections have ½″ N.P.T. threads, regardless of meter capacity.

W & T Armored Purge Meters are engineered to give stable indicating performance even at low gas pressures. A unique snubber washer is used in gas measurement and is combined with the plug float to assure true readings down to atmospheric pressure.



A magnetic indicator travels on the inside surface of a precision-bore scale tube, reducing friction and giving immediate response to varying flow rates. The scale tube is calibrated with both water and percentage scales.

Catalog No. 510.200, describing this new line, gives full selection and specification tables.

Circle No. 14 on Reader Service Card

MAXIMUM STABILITY IN NEW DISPERSION OF COLLOIDAL MOLYBDENUM DISULFIDE IN ISOPROPYL ALCOHOL DEVELOPED

A highly stable, concentrated dispersion of colloidal molybdenum disulfide in isopropyl alcohol, designated 'dag' Dispersion No. 210, has been introduced by Acheson Colloids Company, a division of Acheson Industries, Inc.

When diluted with compatible diluents to the most satisfactory solids content, 'dag' 210 reportedly forms a tightly adherent film which is applicable to a variety of substrate materials with minimum, if any, surface pretreatment. The fast-drying, film exhibits the high-pressure, high- temperature lubricating and release properties inherent with molybdenum disulfide.

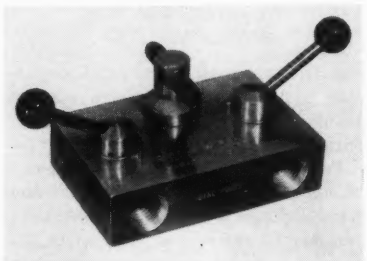
Further information and a complimentary sample of 'dag' Dispersion No. 210 is obtainable.

Circle No. 15 on Reader Service Card

NEW MANIFOLD VALVE AVAILABLE

A new type compact and leakproof manifold valve, P-727 Series, containing three valves in one unit, is now available from Circle Seal Products Company, Inc., Pasadena, California. The P-727 is designed for use with differential-type measuring, recording or transmitting instruments in chemical plants, refineries, pilot plants, test labs and research labs.

The P-727 is said to be maintenance-free, does not require valve seat replacements and no operating adjustments are needed. Valve position is shown instantly by toggle-type handle position, and the "T" handle of the balancing valve is color-coded for ready identification.



The Circle Seal design feature of using "O" rings set in grooves on the diameter of the valve plugs prevents interport and body leakage. "O" rings set in grooves on the face of the plugs provide a dead-tight shutoff. Because these "O" rings seal automatically, the P-727 is claimed to feature effortless fingertip operation.

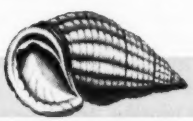
Circle No. 16 on Reader Service Card

Wherever in the world your industrial machinery operates...

Shell Alvania Grease is there

Other outstanding Shell Industrial Lubricants available world-wide

- **Shell Tellus Oils**—for hydraulic systems
- **Shell Talona R Oil 40**—anti-wear crankcase oil for diesel locomotives
- **Shell Rimula Oils**—for heavy-duty diesel engines
- **Shell Turbo Oils**—for utility, industrial and marine turbines
- **Shell Dromus Oils**—soluble cutting oils for high-production metalworking
- **Shell Macoma Oils**—for extreme pressure industrial gear lubrication
- **Shell Voluta Oils**—for high-speed quenching with maximum stability



AN INTERESTING FACT!
Every Shell Branded Industrial Lubricant is named for a sea shell. Shown here is the Alvania beanii.

Around the world, Shell Alvania Grease is available—under the same brand name and providing the same outstanding lubrication. This is assurance that your customers abroad will enjoy the same performance from your equipment that domestic customers rely upon.

Alvania® Grease offers these performance-proved advantages: (1) It provides safe lubrication at both high and low temperatures. (2) It won't wash out even in locations where water splashing can't be avoided. (3) It has built-in protection against rust and pitting of anti-friction bearings. And because this *one* multi-purpose grease is specially designed to satisfy as much as 90% of industrial grease needs, less servicing time is required; inventory costs are less; and there is less risk of misapplication.

No matter where your machinery is shipped, make Shell Alvania Grease your standard recommendation. Write for complete information.

SHELL OIL COMPANY

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100 BUSH STREET.....SAN FRANCISCO 6, CALIFORNIA
IN CANADA: SHELL OIL COMPANY OF CANADA, LIMITED
505 UNIVERSITY AVENUE.....TORONTO 2, ONTARIO

SHELL

PRODUCT LITERATURE

MIST COOLANT APPLICATION TIPS GIVEN IN NEW BOOKLET

Application methods for a variety of standard machining operations are both shown and explained in a new six-page, gate-fold booklet now being offered by Bijur Lubricating Corp., Rochelle Park, N. J.

Using the firm's own Spraymist engineered mist coolant equipment, the booklet covers application methods for the following: end millings, face slab and side milling, tapping, tool and cutter grinding, surface grinding, boring-rotating and stationary tool, turning, drilling - reaming, internal grinding and sawing. Uses for Spraymist other than applying water base coolants to metal cutting are also listed.

Circle No. 17 on Reader Service Card

DATA SHEET ON PIPE LINE STRAINER RELEASED

A comprehensive two-page data sheet with detailed information and specifications on their complete line of pipe line strainers has been announced by the Air-Maze Corporation of Cleveland. Air-Maze manufactures filters engineered to fit readily into lube oil, hydraulic or air pipe lines to remove scale, core sand, metal chips or construction dirt.

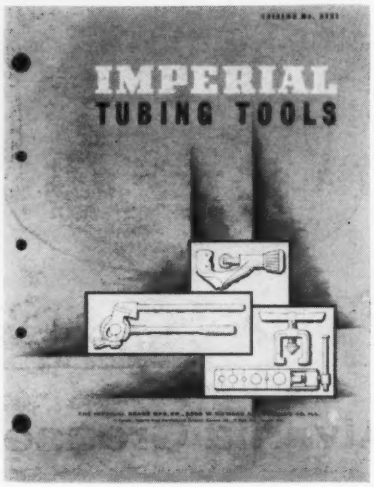
Copies of the free literature may be obtained.

Circle No. 18 on Reader Service Card

NEW TUBING TOOL CATALOG PUBLISHED

Imperial's complete line of tubing tools is presented in a new 32-page catalog by The Imperial Brass Mfg. Co. of Chicago, Illinois. Catalog No. 3121 is of interest to anyone who deals with tubing in such fields as maintenance, instrumentation, plumbing, heating, air conditoning, automotive, farm and other mobile equipment.

The catalog shows over 75 different Imperial tools and kits for all tubing work—cutting, flaring, bending, reaming, swaging, pinch-off, refacing and sizing. It also contains complete data on such miscellaneous items and service aids as test caps and plugs, air nozzles, blowers, machinery cleaners and drum faucets.



Also is included a comprehensive 5-page Replacement Parts List for Imperial Tools and Service Aids along with a listing of pertinent Federal Specifications which apply to over 40 Imperial Cutting, Flaring and Bending tools. Tubing Tool Catalog No. 3121 is available on request.

Circle No. 19 on Reader Service Card

NEW CATALOG AVAILABLE ON ZERO-MAX STEPLESS VARIABLE SPEED DRIVES

A new 16-page, two-color catalog of "Zero-Max" stepless variable speed drives for fractional horsepower applications is now available free from the Zero-Max Company. Typical applications is now available free from the Zero-Max Company. Typical applications are both listed and pictured. Operating features and installation suggestions are accompanied by numerous diagrams and tips on power transmission.

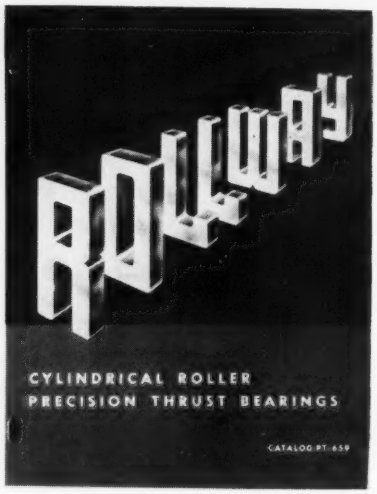
Details are given on all types of units, with or without motor, in the new "400 Series" of "Zero-Max" variable speed drives. Charts and diagrams answer questions on the use of mechanical variable speed.

Circle No. 20 on Reader Service Card

NEW THRUST BEARING CATALOG FEATURES COMPREHENSIVE DATA

A new catalog of cylindrical roller precision thrust bearings is announced by the Rollway Bearing Company, Syracuse, New York. The catalog features detailed engineering data on the company's improved thrust bearings.

Detailed information on dynamic and static bearing capacities, the company's patented tandem thrust bearings, new sizes of crane hook bearings, and bearing applications are contained in the 28-page publication.



The improved bearings feature retainers made of a specially developed ferrous material known as ROLLUBE. The ROLLUBE retainers have a reduced tendency for surface "welding" between roller and retainer pocket under conditions of marginal lubrication and have wear-resistant properties against bearing steel. The thermal coefficient of expansion is approximately the same as the rollers and the thrust plates.

Circle No. 21 on Reader Service Card

PERSONALS

Robert B. Worley has been appointed Vice President, Lubricating Sales of the Warren Refining and Chemical Co., Cleveland, Ohio, according to an announcement by Ian L. Carmichael, Warren president.

ROBERT B. WORLEY

Dr. Andrew Dravnieks has been named scientific advisor in chemistry at Armour Research Foundation by Dr. George S. Gordon, director of the division.

A specialist in the field of corrosion, Dravnieks comes to the Foundation from the Standard Oil Company (Indiana) where he headed the corrosion section.

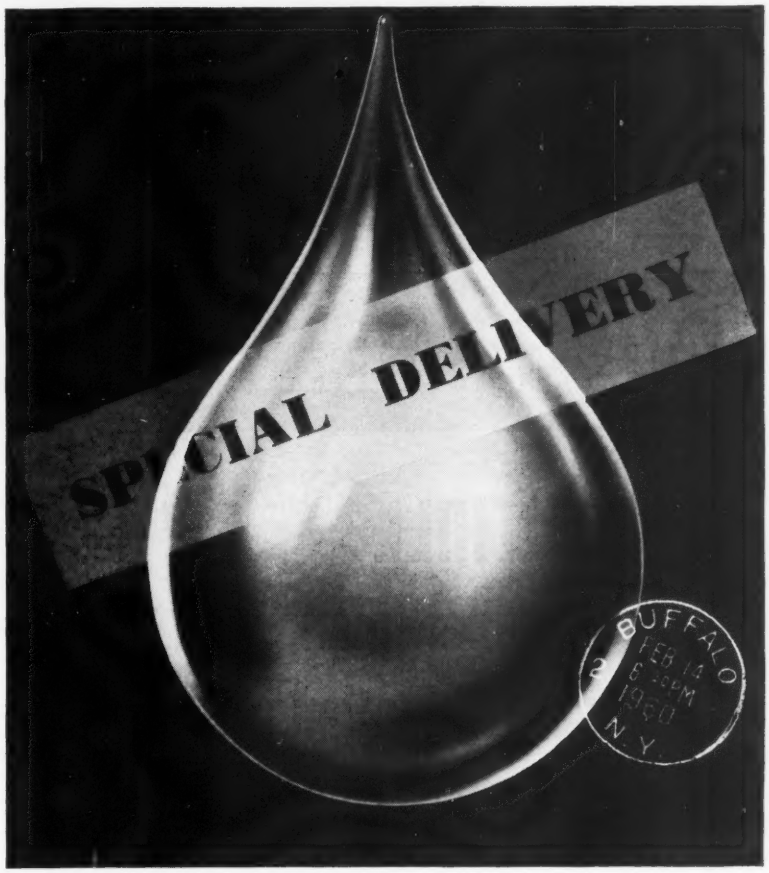
The appointment of Gus Treffeisen as manager of marketing of the Alemite and Instrument Division of Stewart-Warner Corporation, has been announced.

Mr. Treffeisen will direct marketing through distributors and jobbers of Alemite automotive, industrial and other lubrication products, as well as automotive, marine, industrial and other gauge and instrument lines.

A. O. Willey has received the honorary degree of Doctor of Engineering from the University of Maine.

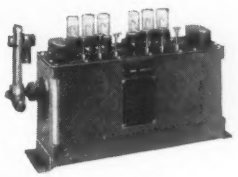
Willey, a graduate of the University of Maine, received his master's degree from there, and was a teacher at the University for five years. He was a member of the faculty of Case School of Applied Science for eleven years, rising to the rank of associate professor. In 1940 he became director of research for Lubrizol Corp. (ASLE Industrial Member), and is now executive vice-president of the corporation. Willey served as a director of ASLE during 1952 and 1953.

HOW FAST should you



deliver a drop of oil?

Whether you're operating high-compression diesels or fast-moving shear knives, you're probably paying more and more attention to lubrication *timing*. Whatever your field, our engineers will be glad to study your requirements and make specific recommendations. Your needs can be met either by adapting an existing model — or we will custom-build you your own lubricating system. Write for our catalog. Manzel, 254 Babcock Street, Buffalo 10, New York. You will get exact, on-time lubrication if you

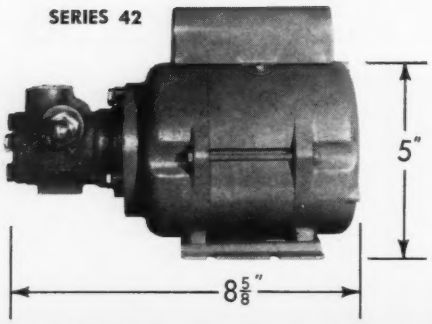


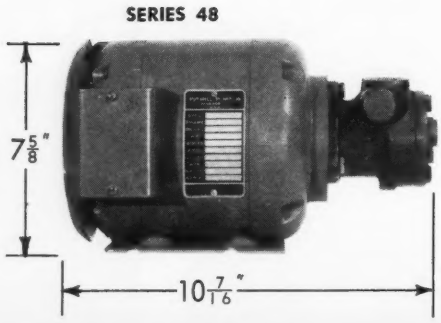
ask the man from

A UNIT OF HOUDAILLE INDUSTRIES, INC.

Manzel

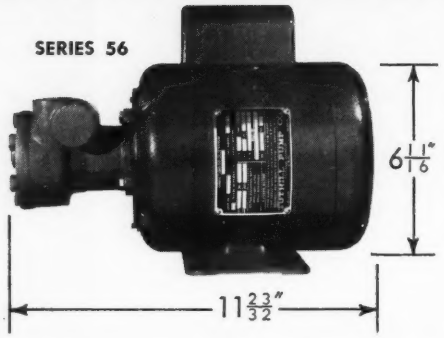
SPECIALISTS IN LUBRICATORS AND METERING PUMPS SINCE 1898





SAVE SPACE...WEIGHT...MONEY

with TUTHILL close-coupled pump and motor combinations



Tuthill close-coupled pumps and motor combinations are especially designed for applications where space is at a premium. Their compactness simplifies assembly operations and lowers production costs. Elimination of couplings, bases and adapters results in significant savings . . . and reduced weight means lower shipping costs.

Tuthill offers a complete selection of units with capacities up to 50 GPM for pressures to 500 PSI. A wide variety of special options is also available. Three standard units are pictured above.

Immediately available from stock

The series 42 units measure only 5"x8 5/8". Their total enclosed ballbearing motors are normally supplied with ratings from 1/12 to 1/6 HP while the pump units have capacities of 20 to 45 GPH at 200 PSI.

Series 48 units, measuring 7 5/8"x10 7/16", are normally supplied with totally enclosed, fan-cooled motors of either split phase, capacitor, or 3 phase construction . . . with ratings from 1/4 to 1/2 HP. They can be supplied with pumps with capacities from 20 GPH to 360 GPH at 200 PSI.

Series 56 units measure 6 11/16"x11 23/32", and are offered in a complete range of motors varying from 1/4 to 1 HP. These can be coupled with pumps with capacities from 20 to 360 GPH at 200 PSI.

Although motors are normally furnished for 1725 RPM they are also available for 3450 and 1140 RPM. Explosion proof construction and double shaft extensions on motors are also furnished in series 48 & 56. Built-in relief valves are optional on all five pump sizes.

Special construction for OEM applications

The units shown plus others in Tuthill's line are immediately available without any quantity restrictions whatsoever.

For those original equipment applications involving substantial quantities, Tuthill's engineers can design and build a POWERMITE . . . an exclusive Tuthill design in which pump and motor are combined in one unit which takes up no more space and weighs no more than a standard electric motor. As an example of the compactness possible a Tuthill POWERMITE now being supplied for a hydraulic application measures only 4 3/4"x8 1/16", yet has a capacity of 16 GPH at 350 PSI.

Tuthill's field engineers will be happy to provide details on the complete Tuthill close-coupled line and its application to your particular problem. If you are trying to fit a pump and a motor into a tight space you should talk to them soon. Call today.

Tuthill manufactures a complete line of positive displacement rotary pumps in capacities from 1/3 to 200 GPM; for pressure to 300 PSI; speeds to 3600 RPM.

PUMPS FOR YOUR PURPOSE

TUTHILL PUMP COMPANY

971 East 95th Street, Chicago 19, Illinois

SECTION NEWS

Pope Elected Honorary Director, Kingsport Section

In one of the first actions of its kind, the Kingsport Section elected C. L. Pope, Eastman Kodak, an Honorary Director. To those who know him, this is, indeed, a tribute to his outstanding record in the field of lubrication. When asked about this honorary directorship, the Kingsport Section replied, "Charlie, as you know, is one of *the* plant lubrication engineers in this country and probably in the world. He comes closer to being the godfather of the Kingsport Section than any other one man. His contributions to the accomplishments of this Section in general and the discharge of lubrication engineering duties at individual plants cannot be measured in anything except appreciation. He is a most unusual man, whose technical and practical abilities have assisted us all in improving operations in our plants."

★ ★ ★ ★ ★ ★ ★ ★

INDUSTRIAL LUBRICATION CONFERENCE

Sponsored by

ASLE Kingsport Section and

ASLE Kingsport Section and University of Tennessee, Mechanical Engineering Department at the University of Tennessee

Oct. 31 and Nov. 1, 1960

"Increase Your Profits Through Improved Lubrication"

Monday, October 31—SEALS AND BEARINGS

First Session: Money Saving Seals and Packings

"How to Select Seals and Packings for Long Life by Compatibility with Modern Hydraulic Fluids," by J. Norton Smith, E. F. Houghton Co.

"Specialized Mechanical Seals for Pressurized Systems," by William M. Watkins, Fulton-Sylphon Co.

Speakers Question and Answer Panel

EXHIBITS AND LUNCH

Second Session: Increase Profits Through Bearing and Selection, Inspection, and Lubrication

"Reduce Down Time—How? Pre-Inspect Your Bearings," by C. L. Miller, Eastman Kodak Co.

"Cut Costs—How? Use Programmed Maintenance," by T. R. Witt, Eastman Kodak Co.

"Selection of Sleeve or Rolling Element Bearings for Greater Economy," by C. L. Pope, Eastman Kodak Co.

Speakers Questions and Answer Panel

Tuesday, November 1—CORRECTIVE PRACTICES FOR POTENTIALLY DANGEROUS SERVICES

Third Session: "Less Hazardous" Lubrication Fluids

"Evaluation of a Fire-Resistant Fluid in a Circulating System," by E. J. Tullos, Union Carbide Nuclear Co.

"A Survey of Recent Developments in 'Less Hazardous' Hydraulic Fluids," by Thomas G. Smith, Celanese Corp. of America.

"The Lubrication as Cause or Prevention of Fires and Explosions in Compressed Air Systems," by Robert S. Ridgway, Standard Oil Co. of California.

Speakers Question and Answer Panel

Fourth Session: General

"Synthesized Fluids for High Temperature Service," by L. Powell Foster.

"New Media Minimize Olf Filtration Problems," by John Farris, Aircraft Porous Media, Inc.

"Pros and Cons of Multiple Viscosity Oils with and Without VI Improvers," by C. E. Hulme, Kendall Refining Co.

Speakers Question and Answer Panel

For further information write: Paul E. Walker, Secretary-Treasurer, Kingsport Section, Esso Standard Oil Co., P.O. Box 950, Knoxville, Tenn.

★ ★ ★ ★ ★ ★ ★ ★

CHICAGO SECTION—The Chicago Section will sponsor an Education Course in six sessions beginning, Friday, September 30 and each week thereafter for a period of six weeks. The following topics will be covered:

Fundamentals of Lubrication—The lubrication engineers lubricant testing manual will be discussed.

Automotive Lubricating Systems—With a panel discussion on plant lubrication programs.

Seals and Packings—Metal Working Operations and Metal Working Fluids.

Hydraulic Fluids—Automotive and Engine Lubrication Properties of Oils and Greases and Dry Film Lubrication.

For further information contact: Mr. Norman T. Bauer, Acheson Colloids Company, 510 No. Dearborn St., Chicago 10, Illinois.

EN-AR-CO OILWAYS YOUR BEST FRIEND
EN-AR-CO Promax CUTTING OILS
EN-AR-CO C1 MOTOR OIL HD
EN-AR-CO Tectyl ANTI RUST OILS
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EN-AR-CO PETROLEUM PRODUCTS
Serving industry with the finest cutting oils and lubricants for over three quarters of a century.
Our staff of highly trained engineers is prepared to help you solve the most stubborn lubrication problem in your plant.
Write, wire or phone today
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A DIVISION OF ASHLAND OIL AND REFINING COMPANY

NEW ASLE MEMBERS— JULY 1960

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FRED N. KLOOSTER
Famous Lubricants, Inc.
Chicago, Illinois

JOHN Q. MAGIE
Magie Bros. Oil Company
Franklin Park, Illinois

CHESTER A. MITCHELL
The Loyal Group
Chicago, Illinois

MELVIN P. RILEY
Magie Bros. Oil Company
Franklin Park, Illinois

CLEVELAND

PETER C. PATERSON
Timken Roller Bearing Co.
Canton, Ohio

FRED EBOCH
International Rustproof Corp.
Cleveland, Ohio

PITTSBURGH

ROBERT W. CORBOY
Alemite Co. of Pittsburgh
Pittsburgh, Pennsylvania

LOS ANGELES

DARYL D. LIEBERMAN
Pemaco, Incorporated
Los Angeles, California

RICHARD G. WILLING
Microtech Div., Federal
Mogul Bower Bearings, Inc.
El Monte, California

NEW YORK

C. DEAN NEWNAN
Oronite Chemical Company
New York, New York

PHILADELPHIA

WILLIAM U. REYBOLD, JR.
Haveg Corporation
Wilmington, Delaware

J. P. WISDOM
Cities Service Oil Co.
Bala-Cynwyd, Pennsylvania

DETROIT

NORMAN A. HUNSTAD
GM Research Laboratories
Warren, Michigan

DAYTON

HAMILTON R. SMITH
Wright Air Development Div.
USAF—Wright Patterson AF Base, Ohio

ST. LOUIS

DALE F. SMITH
Monsanto Chemical Company
St. Louis, Missouri

YOUNGSTOWN

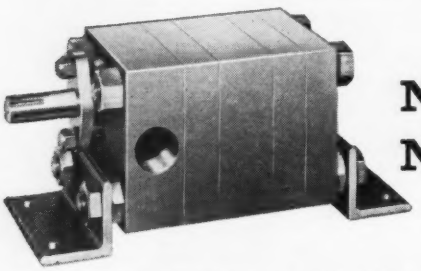
WILLIAM C. SMILEY
The Pure Oil Company
Tallmadge, Ohio

UNAFFILIATED

JAMES A. EANES
Lion Oil Company
El Dorado, Arkansas

NORMAN H. GERBER
Ethyl Corporation
Tulsa, Oklahoma

for pumps as individual as a fingerprint!



SPECIFY NORTHERN NITRALLOY PUMPS

Northern designs and builds quality into every pump. For each application, materials are selected with infinite care—gears with ground tooth form for perfect contact, correct clearances. Meticulous inspection at every stage in the manufacturing process assures efficient, economical, lasting service for even the most difficult pumping tasks under rugged conditions, indoors and out, year after year.

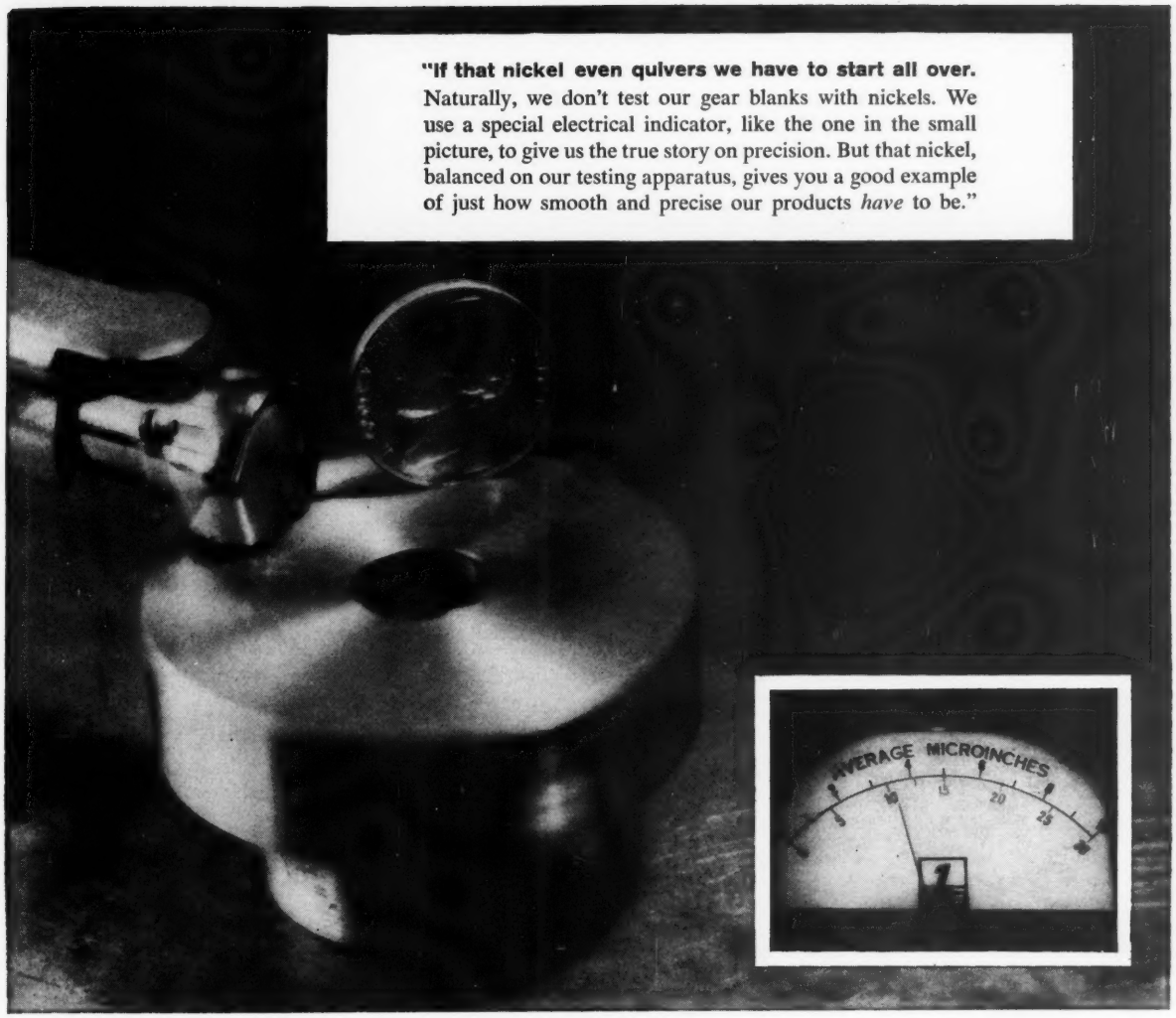
Northern Nitralloy Pumps are available in capacities from ¼ to 146 GPM at pressures up to 2000 PSI. Within this range there is a pump as individual as a fingerprint — as "special" as you want it.

Write today for free catalog and engineering data.

Northern Ordnance Incorporated
Subsidiary of NORTHERN PUMP COMPANY
Minneapolis 21, Minnesota

A MOMENT OF REFLECTION . . .

Paying your membership dues is one way of supporting ASLE . . . its programs . . . its activities. **Participating** in the programs and activities of the Society . . . designed for your benefit . . . is another. **Procuring** a new member who is interested in the science of lubrication and the work of the Society is still another . . . These three P's represent what is needed of members to make ASLE the organization it has a right to be.


"If that nickel even quivers we have to start all over.
Naturally, we don't test our gear blanks with nickels. We use a special electrical indicator, like the one in the small picture, to give us the true story on precision. But that nickel, balanced on our testing apparatus, gives you a good example of just how smooth and precise our products *have* to be."
AVERAGE MICROINCHES
5
10
15
20
25

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Vol. 16, No. 9

Lubrication Engineering

The 1960 Joint Lubrication Conference

One of the technical highlights of the year for Lubrication Engineers is rapidly approaching. The 1960 ASME-ASLE Lubrication Conference program will include papers on a wide variety of research and development subjects in the field of lubrication. Problem areas to be discussed include work at extreme low and extreme high temperatures and in unusual environments. All types of conventional and several non-conventional lubricants will be described. Gears, seal materials, rolling contact bearings, gas bearings, and fluid film bearings provide the design components of interest. Mechanisms of boundary lubrication, wear, sliding friction and rolling friction will be described that will provide stimulating discussions. The sessions including discussion periods will be under the guidance of Session Chairmen that are recognized authorities in their fields.

Eight technical sessions will be presented during the meeting at the Statler Hotel in Boston on Monday, Tuesday, and Wednesday, October 17, 18, and 19. Two concurrent sessions will be held on the morning and afternoon of Tuesday the 18th.

The meeting will have an international character, since authors from West Germany, Great Britain, and Japan are to be represented. Starting with more than 70 papers offered for the meeting the Planning Committee selected 30 (17-ASLE, 13-ASME) for the program. Each paper has been subjected to a rigorous technical review and was carefully evaluated. One of the disappointments of preparing this program has been the lack of a sufficient number of sessions to include all of the valuable papers that were offered. It is, however, gratifying to realize that the conference has obtained a level of recognition as a technical forum so that many research workers from all over the world are willing and eager to provide papers.

You may be assured that attendance at this conference by Lubrication Engineers will be time well spent. Plan to enjoy the conference and Boston hospitality on October 17, 18, and 19. The local sections of ASLE and ASME are hard at work to help make this meeting both a technical and social success. We are sure that the plans for a social hour on the 17th will, in particular, meet with your approval.

Robert L. Johnson
Vice Chairman,
Joint Conference Committee

Precise Duplication by Hydraulic Tracing

by Herman Horlacher and Benjamin W. Carter,
The Cincinnati Milling Machine Co., Cincinnati, Ohio

Presented at the 15th ASLE Annual Meeting, Cincinnati, Ohio, April, 1960

Basic variations of hydraulic tracing are single axis systems and multiple axis systems. Multiple axis systems may be further subdivided into the categories of tracers which are guided manually and automatic tracing systems which are self-guiding. The basic principle of all varieties of present-day hydraulic tracing systems is the hydraulic servo system. In all of these systems, some form of an hydraulic servo valve is the core of the actual tracing device.

Hydraulic machine tool tracing systems must be engineered to consider not only the actual tracing component but also actuators, pumps, and oil handling arrangements. In addition, physical machine parameters such as stiffness, friction, and inertia are important issues in overall system design. Every component of a servo mechanism plays an active role and a hydraulic tracing system is no exception.

INTRODUCTION

Contour milling made its appearance in the early twenties. The movement of the milling cutter was obtained by means of a template and a follower attached to the carrier. Obviously, the limitations of this method consisted of the rapid increase of the pressure component when milling steep configurations and the associated non-uniform cutting velocity. These short-comings vanished with the employment of the hydraulic servo principle as a guidance system for contour milling. The basic hydraulic principle is analogous to the well known electrical Wheatstone bridge and substitutes electrical with hydraulic resistances. (Fig. 1)

The practical application has demonstrated its superiority over previous methods. It permits the tracing of complex configurations accurately and effortlessly.

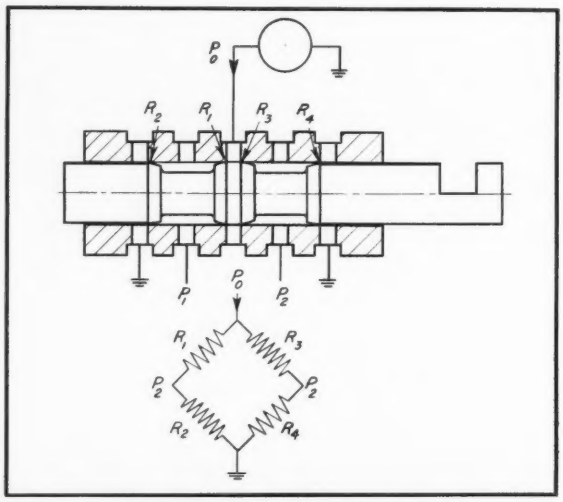


Fig. 1. Valve Design Wherein Resistance of Ports Form The Elements of a Hydraulic Wheatstone Bridge.

SINGLE AXIS TRACING

The simplest type of tracer used is the single axis tracer. (Fig. 2) This tracer consists of a body, bushing, plunger, stem, and arm. The tracer body contains the bushing, which contains the porting grooves and is usually ground to a tight fit with the body. The body also provides a means for attaching the hydraulic connections, either threaded or gasket mounted, and sometimes is used for mounting the unit to the machine. The plunger is ground and lapped to a close sliding fit in the bushing. Its ports connecting pressure or exhaust to one or the other end of the actuator are then calibrated. The tracer stem is mounted on the body and retains the arm. Sometimes the stem and body are made in one piece. A hole is provided in the end of the arm into which the tracer stylus or finger is mounted. The function of the arm is to transmit movement of the finger to movement of the plunger.

The calibrator at the hydraulic test stand grinds the porting shoulders on the valve plunger to certain specifications which are calculated for the machine parameters.

The quantity of oil flow to the machine actuator is a function of the pressure drop and the porting area. The pressure drop and porting area are obtained by the plunger moving off its null position. Well calibrated tracer valves register 20 psi pressure differential when deviating from null less than 25 millionths of an inch. The farther the valve plunger is displaced from null the greater the flow of oil. This movement indicates the relation of accuracy to speed. The amount of movement of the stylus from neutral is the difference between the cutter contour path and the template contour.

A single axis tracer may have to handle a large capacity of oil due to high feed rates. As previously mentioned, the valve plunger and stylus movement dictates the rate of travel and a larger error will result when tracing at high feed rates. This larger error could be eliminated if the cutter would remain in a fixed relation with the tracer finger or stylus (Fig. 3). To accomplish this the spindle carrier, supporting the cutter, can be mounted on a separate compensating slide controlled by a compensating valve. The function of this compensating valve is to move the spindle carrier the same distance the stylus is deflected. This should keep the cutter and stylus in a fixed relation and very little error will develop.

To reduce the large error, without using a compensating slide, the template can be altered to compensate for the greater stylus deflection, but this is done mostly by trial and error.

A light duplicator slide designed and built with care and rigidity can accurately follow a small tracer signal at a high velocity without oscillation.

The traverse (table) slide, which supports the work and contour template, may be powered mechanically, but in most applications this slide is also powered by a hydraulic cylinder or motor. (Fig. 4) When this slide is not controlled by the tracer, the traverse feed rate is usually held constant. Therefore the tracer valve plunger will be excessively deflected to give the required speed to the tracing slide as the angle on the template increases. A 90° angle could not be traced without the operator stopping the traverse slide. To make this automatic, additional control ports can be added to the tracer valve spool to control the traverse feed actuator. These ports are calibrated to pass the oil required for the maximum feed rate with the tracer plunger at its neutral or central position. As the angle

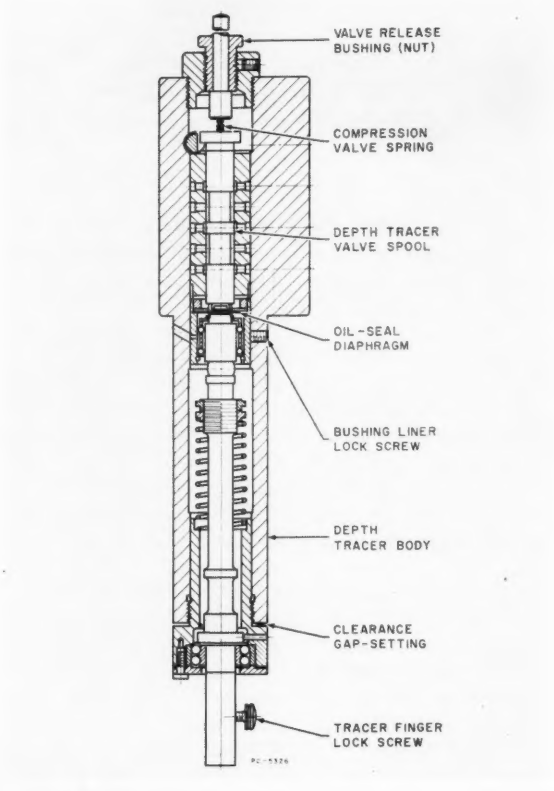


Fig. 2. Single Axis Tracer Valve.

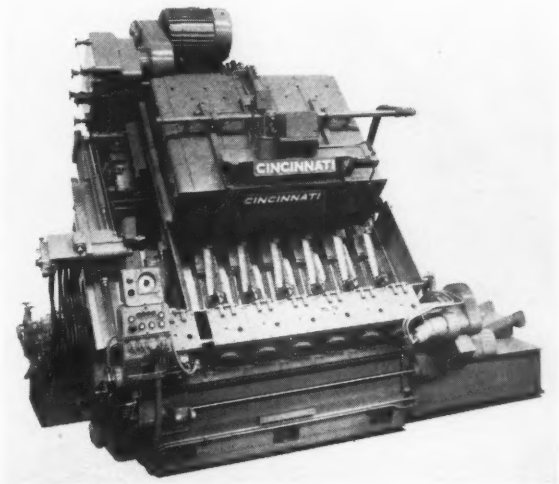


Fig. 3. Six Spindle Turbine Blade Milling Machine.

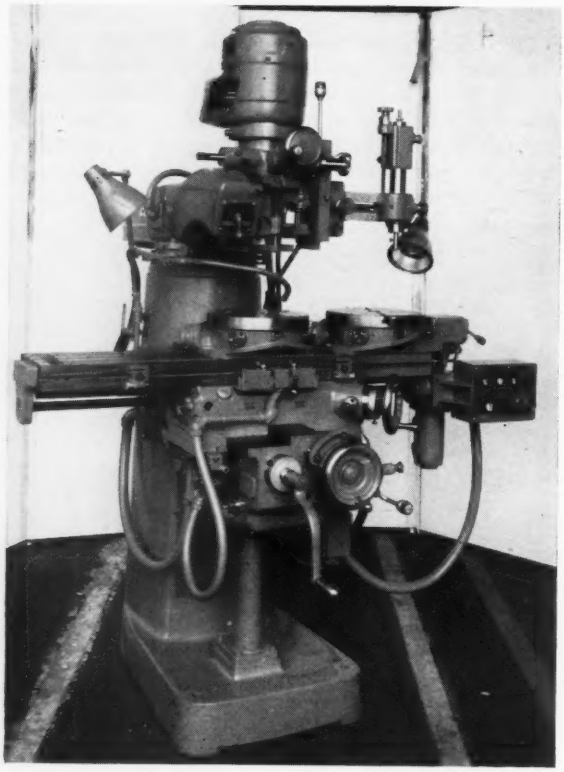


Fig. 4. Tool and Die Milling Machine With Hydraulic Depth Tracer and Duplex Hydraulic Rotary Table Attachment.

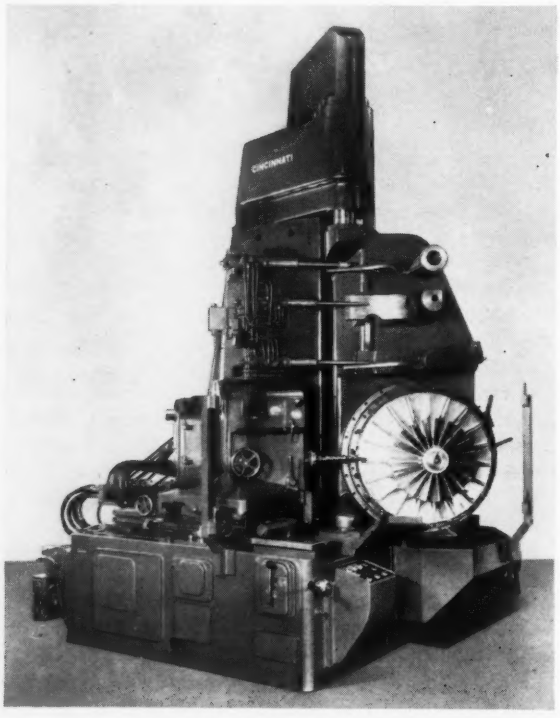


Fig. 5. Special Profile Milling Machine Equipped With Four Simultaneous Depth Tracers.

on the template increases the tracer plunger will be deflected from its neutral position decreasing the flow of oil to the traverse actuator. As the angle on the template increases to 90° the tracer plunger deflection will increase until the oil flow to the traverse slide is shut off by the tracer plunger, thus stopping the table automatically. An automatic cycle can be arranged by providing trip dogs on the table with pickfeed on the slide which is at 90° to the table.

There are designs where several axes are controlled by individual tracers and each operates off its own contour template. (Fig. 5)

Such machines can also produce very accurate work since each tracer is calibrated for its slide parameter and the overall performance is a function of the machine design and workmanship.

The single axis tracer is used today in a great variety of tracing applications. Factory built standard machines incorporating these tracers permit full automatic cycling of machines for precise duplication.

SINGLE AXIS STYLUS

The tracer stylus should be the same size as the cutter if it is confined to move only axially in the same direction as the cutter.

If the tracer arm is designed to allow side movement as well as end movement to retract the tracer slide, the stylus must be made larger than the cutter. The stylus diameter should be larger than the cutter diameter by twice the amount of stylus side movement to bring the tracer plunger to its neutral position from the hang free position, plus an allowance for the velocity error due to feed rate and climb angle. The hang free position is the position the stylus assumes without touching the template.

360° PROFILE TRACING

The common two axes control is generally known as 360° profile tracing. There are two valves in this tracer, each controlling one axis.

The machine is designed with two slides perpendicular to each other. The motive power for the slides is a cylinder or hydraulic motor. Similar to the single axis tracer slide, mentioned in the first part of this study, both slides must move freely and the 360° tracer must be rigidly mounted to one slide. The two valves which operate the two slides are arranged so that deflection in the direction of the X-axis moves the valve for this slide while the other valve controls the Y-axis. The X and Y deflections are sine and cosine functions since the movement on the stylus or tracer stem is a function of its position in the quadrant of a circle. As the stylus is deflected in either of the two axes or a combination of both, the tracer valves shift off neutral accordingly and cause movement of either, or a combination of both, slides. The speed of the two slides is a direct relation to the deflection of each of the two tracer valves.

360° profiling tracers are available in both hand-guided and completely automatic types.

360° HAND PROFILE TRACING

The simplest version of 360° profile tracing is the 360° Hand-Guided Tracer. (Fig. 6)

By manually holding the tracer finger against the template or master and displacing it tangent to the template, hand 360° profile tracing is obtained in the horizontal plane combining the movement of the table and saddle.

By adding a depth control valve to this unit, hand 3-D or simultaneous depth and profile tracing is accomplished by manually displacing the tracer finger tangentially to the surface of the master to follow the horizontal contour, and at the same time manually raising or lowering the tracer finger in a vertical plane to follow the vertical contour.

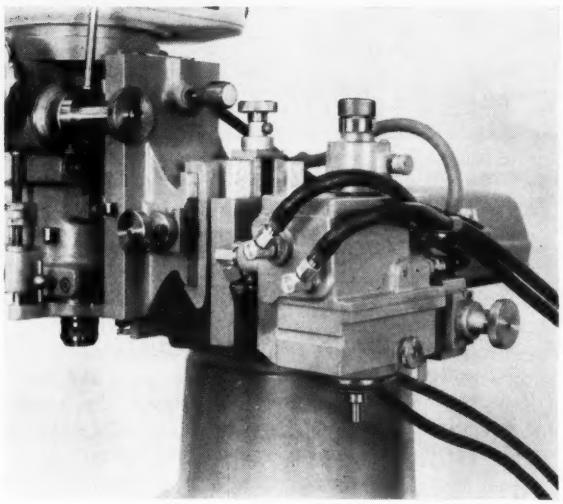


Fig. 6. Three Dimensional Hand Guided Hydraulic Tracer Mechanism.

Horizontal feed rates of the tracer are under full operator control at all times. The farther the tracer finger is displaced the greater the feedrate. The maximum feedrate is predetermined by adjusting a knurled ring above the tracer finger, which limits the displacement of the finger. The maximum 360° profile tracing rate on the type of machine shown in Fig. 7 is about 50 inches per minute, although it can be built for greater feed rates.

A retraction knob is provided which raises the tracer and cutter to the upper or retracted position. When in this retracted position a rapid traverse rate is provided for positioning of the table or saddle without changing the setting of the feed rate dial.

The movement of the table and saddle on this duplicating machine when under tracer control, is actuated by hydraulic motors driving the lead screws. A double, preloaded ball bearing nut is used on the lead screw to eliminate backlash.

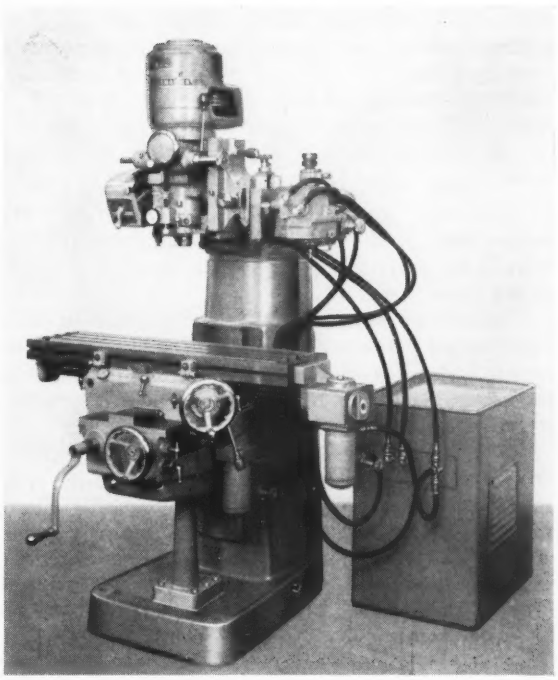


Fig. 7. Tool and Die Milling Machine With 3-D Hydraulic Tracer.

Oil to the table or saddle motors can be independently shut off while depth tracing. The operator controls the vertical movement of the spindle and the feeding slide movement from the tracer finger. He controls the progression slide with its handwheel while that motor is shut off. When operated in this manner, the tracer finger must be mechanically restricted from deflecting in the progression slide direction to prevent tracing errors. The steering deflector contains this restriction.

Semi-automatic operation is accomplished by setting the steering deflector knob, which can be revolved 360°, in the desired direction of movement. It spring biases the tracer finger in that direction and will keep it on the template for shallow profiles or straight cuts without operator attention.

Hard metals are normally difficult to machine by hand tracer control because of the low feed rate requirements. An aid to the operator is the ability to preset the "down" and "up" feed rate of the cutter for smoother control and less cutter breakage.

Another advantage of this tracer design is that the tracer finger and cutter are the same diameter without any oversize allowance for initial deflection. In the case of a roughing cut where stock is to be left on the workpiece, an oversize tracer finger is used.

The design permits this unit to be used as a depth tracer with pickfeed. Provision is available to compensate the linear rate of travel when steep angles are encountered on the template. The tracer can also be

equipped with means for automatic steering along profiles. Accuracies on this kind of duplicating attachment is as close as ± .001 at low feed rates. It can handle oil volumes up to 8 gpm.

360° AUTOMATIC PROFILE TRACING

The 360° automatic profiling tracer follows the outline without the help of an operator. Its steering is by hydraulic means (Fig. 8). The stylus is eccentric on the tracer stem.

The tracer stylus diameter is larger than the cutter diameter by twice the amount of stylus side movement to bring the steering plunger from its hang free to its neutral position. No allowance is needed for velocity error due to feed rate.

The stem rotates by means of a hydraulic motor, and a steering valve controls the direction of the stem rotation. The rate of feed along the contour is infinitely variable within the practical feed ranges of the machine. The stylus progresses automatically along the profile cam, and the angles on the template are unlimited. The rate of advance corresponds with the selected rate which may be remotely controlled. (Fig. 9). The angle of stylus contact does not affect the feed rate. 100 inches/min. feed rates are available with this unit.

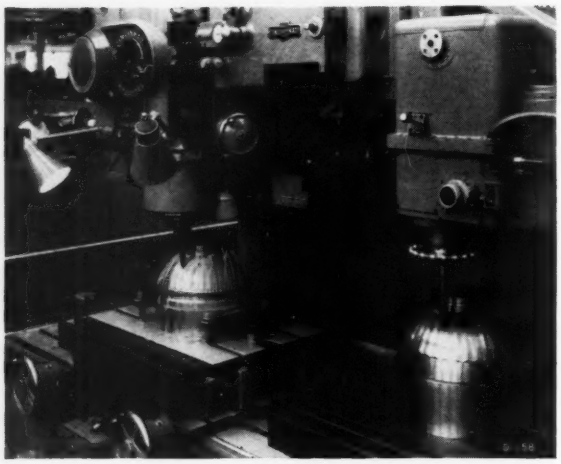


Fig. 8. Die Sinking Milling Machine With Universal Automatic Combination Hydraulic Tracer.

THREE DIMENSIONAL TRACING

This automatic tracer is designed for three dimensional tracing with a selector lever for depth alone, 360° alone or all three dimensions simultaneously. On this type of duplicating device feed rates as high as 100 inches/min. can be obtained on certain types of machines.

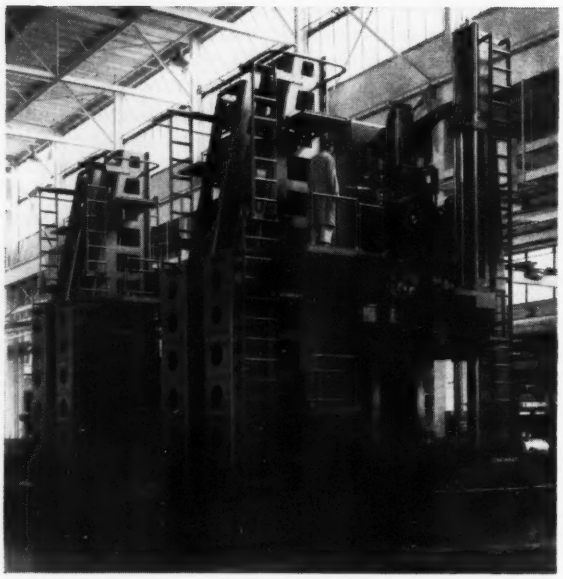


Fig. 9. Traveling Column Horizontal Milling Machine With Automatic 3-D Tracer.

SUPPORTING DESIGN FEATURES

No matter how well a tracer is designed and built, it is only one link in the chain. Therefore, the following machine factors are indispensable in achieving over-all optimum performance.

1. Mechanical Structure

The mechanical structure of the machine must be very rigid to prevent any deflection of the tracer mechanism or other machine elements.

Deflections or vibrations in the tracer mounting or machine structure, as little as 25 millionths of an inch, will affect the tracing value. It is therefore imperative that these deflections be kept to a minimum if accurate reproduction is desired.

The hydraulic motor or cylinder which transforms the oil flow from the valve to slide movement must be rigidly mounted so that a minute oil flow actually causes movement of the slide and does not merely result in mechanical deflections.

2. Actuator Size

Proper size of the motivating cylinder or motor is another requirement for precise duplication. The smaller the differential pressure to cause slide motion the more exact the duplication. The designer must select the cylinder size so that the unloaded slide will move with a pressure differential of 50 psi or less.

3. Bearings

The slide bearings should be designed for maximum rigidity and alignment with minimum friction. Most of the slide bearings are precision machined and scraped. Others are hardened and ground, and occasionally some are provided with rolling contact bearings.

4. Lubrication

Lubrication for the slideways is most important. It is best to arrange for flood lubrication. This means an excessive amount of oil is continuously supplied under pressure to the ways. The excess is collected and drained back to the tank.

Another method for lubricating the ways is the use of pressure lubricators distributing oil to the various points needing lubrication. Such lubricators are usually operated as a function of the slide movement. It is essential that the lubrication of the ways be designed to assure proper oil distribution even under heavy loads.

While following a contour, the slides may change their velocity from zero to a maximum. At extremely slow speeds the slide may jump or tend to stick-slip. It would be desirable to have the friction factor throughout the speed range constant to minimize the jump, but it is known that the coefficient of friction has a relationship to the speed and this factor varies considerably.

The type of oil used should be a non-corrosive sulphur, extreme pressure base type oil. The specifications should include a test for stick-slip, whereby the ratio of coefficients of static friction to kinetic friction shall be less than one.

5. Power Requirements

The horsepower capacity of the machine for metal removal determines the push required by the slide. Best duplicating performance is obtained when the supply pressure is over 300 psi.

Good control of the slide is maintained when the pressure difference on the cylinder does not exceed ⅔ of the supply pressure. Since the force required on the slide and the unit pressure available in the cylinder is known, the area of the cylinder is a simple calculation. The combined maximum rates dictate the size of pump.

The pump must deliver its output without vibrations which may affect the work finish. Whenever a variable delivery pump is used it must respond to the requirements of the circuit without causing excessive pressure changes in the system. The selected pump and necessary supply pressure will determine the size of the electric drive motor.

6. Hydraulic Oil

The type of oil usually recommended for tracing systems is a good grade of oil of 145-155 viscosity at 100F with additives to prevent rust, foam, and formation of carbon.

7. Hydraulic Tank

The hydraulic tank should be designed to hold two or three times the quantity of oil the pump will deliver in one minute. The natural heat radiation with this size tank, together with the radiation from the piping, valves, and actuators, should be adequate to keep the hydraulic oil temperature below 120F. A heat exchanger should be provided if this temperature is exceeded.

The tank should have adequate access openings for periodic cleaning. It should be designed to prevent any foreign matter from contaminating the oil, but still allow free air circulation over the surface of the oil in the tank.

Baffle plates should be provided in the tank for directing the returning oil along a path, past permanent magnets, to pick up micronic ferrous particles before the oil is drawn into the pump. All active return lines must be well submerged in the tank in order to eliminate any possibility of foam formation.

8. Filters

Filtration of the hydraulic oil is most important and too often ignored. The tracer valve has at times an orifice opening of only a few millionths. It is therefore, essential to keep the oil free from minute particles which silt the sensitive valve ports or stick the plunger of the tracer by wedging between the plunger and its bushing.

It is advisable to provide a full-flow filter in the pump supply line which will remove all particles of dirt larger than 5 microns.

For super sensitive duplicators, an additional bypass filter must be provided capable of removing particles smaller than one micron. Such systems often employ heating as well as cooling of the hydraulic oil so the temperature is maintained continuously around 110F.

9. Piping

The pressure lines connecting the duplicators, valves, and the slide actuator shall be as short as physically possible and have a minimum of connections. The operating pressure influences the type of flexible hose to be used. It is customary to use synthetic rubber hose with wire braid reinforcement so that hose expansion is minimized with changing pressure.

CONCLUSION

Hydraulic duplication has performed outstandingly for over 30 years in thousands of applications, some with over 20 years of continuous service. Precise hydraulic duplications are a practical reality with today's tracing units, but they must be coupled with the other supporting design features outlined.

Polytetrafluoroethylene Insert Compression Rings in Radial Gas Engines

Presented at the 15th ASLE Annual Meeting, Cincinnati, Ohio, April, 1960

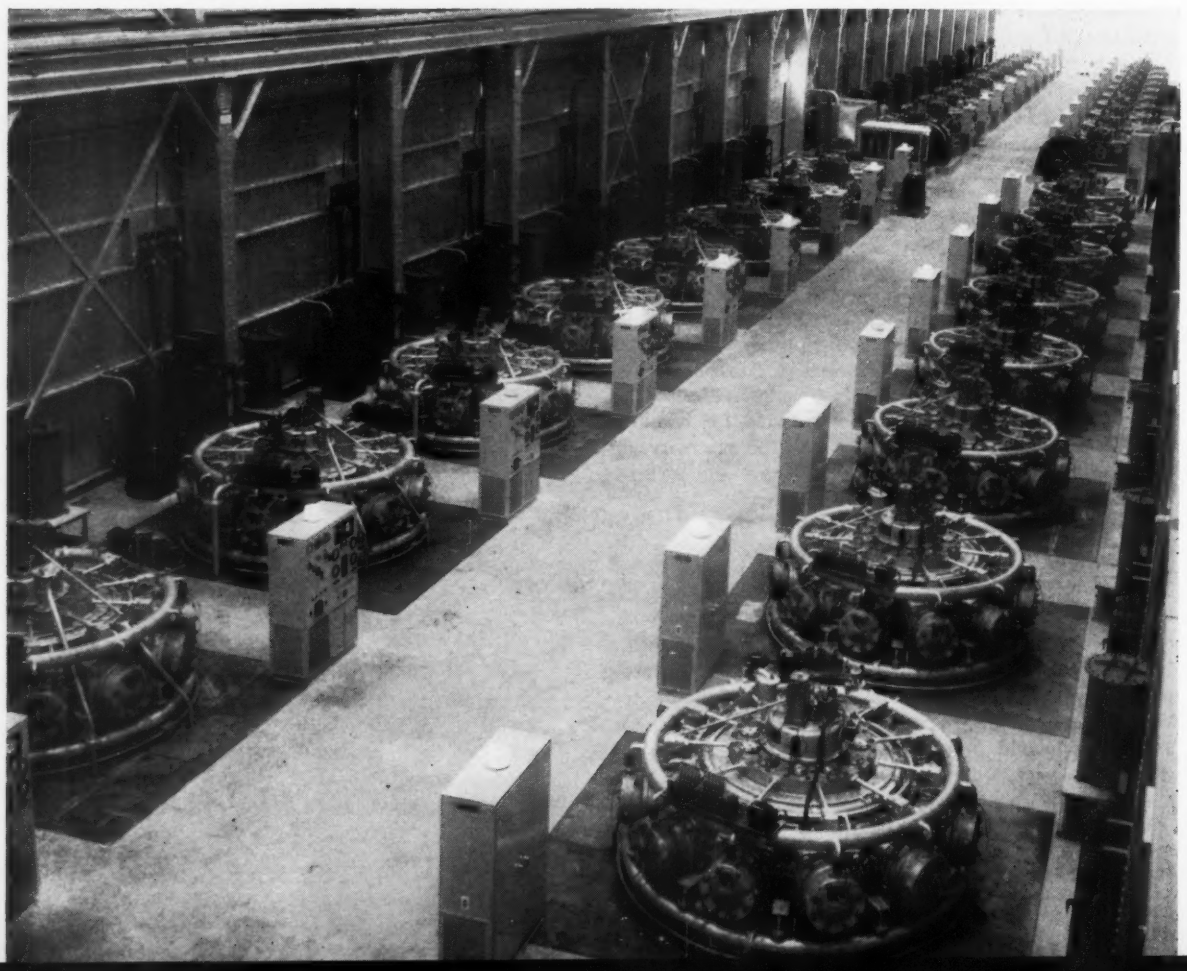
by D. W. Sawyer,
Alcoa Research Laboratories, New Kensington, Pa.
and D. A. Paull,
Sealed Power Corp., Muskegon, Mich.

A cast iron compression ring containing a polytetrafluoroethylene-glass laminate insert has been developed. Full scale engine tests employing both eleven- and twelve-cylinder radial gas engines have been carried out. Test results indicate that these engines will operate successfully when equipped with these rings and the upper cylinder forced-feed lubricators completely shut off, resulting in considerable savings in oil and maintenance man-hours.

HISTORICAL BACKGROUND

A large smelting plant is operated at Point Comfort, Texas for the production of aluminum. The direct current used in operating the seven pot lines in this plant is supplied by a power plant consisting of generators operated by 242 two-cycle radial spark-fired gas-burning engines which supply nearly 600,000 horsepower. Fig. 1 shows an interior view of one of the powerhouses. These engines have a bore of 14 inches, a

Fig. 1. Interior View of Powerhouse Containing 40 Radial Gas Engines



stroke of 16 inches, and are operated at 365 and 400 rpm.

The original installation of 120 engines, which have been in operation since early in 1950, are eleven-cylinder engines, each developing 1800 horsepower. Since the original installation, the plant has been expanded several times, and 122 twelve-cylinder engines have been added. Each of these twelve-cylinder engines develops from 1925 to 2135 horsepower.

Each engine is arranged with port scavenging and port exhaust, and the intake and exhaust are timed by the pistons as they uncover the ports in the cylinder walls. The upper cylinders are lubricated with forced-feed lubricators, which inject the oil into the cylinders at 40 psi.

The engines are of the dry sump type, each requiring 500 gallons of crankcase oil as an initial fill. The lubricating oil is discharged from the engine at a rate of 150 gallons per minute into a reservoir from which it is pumped through a heat exchanger and back again into the engine. Each engine is equipped with a bulk type bypass filter holding 500 pounds of 40-80 mesh Activated Alumina Grade F-3. Oil is by passed through this filter at a rate of 3.3 gallons per minute from the reservoir and back again into the reservoir. At this rate, it takes approximately 2½ hours to filter 500 gallons of oil.

COMPOSITE RING DEVELOPMENT

In view of the large volume of oil required annually for the lubrication of the radial gas engines and the importance of correct lubrication in achieving low repair and maintenance costs, a coordinated laboratory and field investigation was undertaken to study the operating characteristics of the various oils that might possibly be used. The results of this investigation disclosed that excessive ring wear occurred in the field tests with oils having viscosity indices of less than 70, and upper cylinder lubrication appeared to be the most critical factor affecting the lubrication of the engines (1). In addition, it has been found that excessive compression ring wear also occurs when the oil from the forced-feed upper cylinder lubricators is cut off.

Many investigators have reported on the exceptionally low coefficient of friction of polytetrafluoroethylene (PTFE) (2-6). When PTFE is rubbed against a hot metal surface, a minute amount of material transfers to the surface of the metal. In order to determine if the frictional and wear properties of PTFE could be used to advantage in the upper cylinder lubrication of the radial gas engines, a cooperative project between the two authors' companies was undertaken to develop and evaluate a compression ring containing a PTFE insert. If such a development was successful, it would mean a considerable savings in oil, through the elimination of the forced-feed upper cylinder lubricators, as well as in the labor required to keep the upper cylinder lubricators adjusted. Considerable additional man-hour savings can be foreseen in the time required to clean carbon from the exhaust ports in the yearly maintenance program, since the carbon build-up in the ports should be kept at a minimum with the elimination of the upper cylinder forced-feed lubrication.

Although PTFE is chemically stable at temperatures approaching 600-650F, it is lacking in certain physical properties. For example, it has a tendency to flow. However, these deficiencies can be largely eliminated or minimized through the incorporation of a solid filler such as a glass laminate.

DESIGN OF RING

In the initial design, a circumferential groove, 5/32 inch wide by 3/32 inch deep, was cut in the standard 14 inch by 5/16 inch cast iron compression ring and a PTFE-glass laminate insert fitted in the groove and held in place by means of an epoxy resin cement. Fig. 2 is a photograph of this first design and shows the PTFE-glass laminate circumferential insert. One piston in an eleven-cylinder engine operating at 365 rpm was equipped with a set of four of the experimental compression rings and two standard oil rings. In order to determine how these rings would stand up in the engine, the rings were operated with normal lubrication from the upper cylinder forced-feed lubricator for 1,000 hours. The rings were in good condition at the end of this period and the test was continued for an additional 500 hours using one-half normal upper cylinder lubrication. At this point, with the rings still in excellent condition, the upper cylinder oil supply to this cylinder was completely shut off and the test was continued for 11,500 hours. Although a large amount of the insert was found missing from each of the rings at the end of this period, there was no evidence of abnormal ring or cylinder wear.

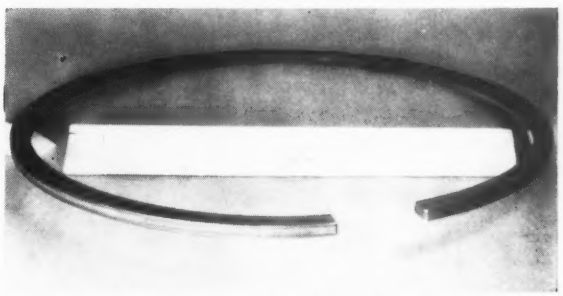


Fig. 2. The First Compression Ring Designed With the Polytetrafluoroethylene Insert. The Insert Is On the Outside Circumferential Side

On the basis of these encouraging wear results, it was decided to equip one eleven-cylinder engine with a complete set of 44 of the laminated PTFE-glass insert rings. The failure of the bond of the insert to the metal with subsequent loss of the insert to the ports indicated the need for an improved adhesive. A separate project was undertaken to study a number of cements in an attempt to overcome this difficulty. The bonding characteristics were evaluated on the basis of tensile tests made in hot oil with the test specimens being bonded to the PTFE-glass laminate. Results of these tests indicated that a completely different epoxy resin adhesive would function satisfactorily.

New rings made with this adhesive were then installed in the eleven-cylinder engine described above. In this test the engine was operated at 365 rpm with the oil flow from the upper cylinder lubricators completely shut off from the start. After 2,646 hours operation, an inspection was made on this unit by removing

the gas valves and cylinder heads from four cylinders. With the exception of the second compression ring in three or four of the pistons, in which sections of the insert were found to be missing, all of the inserts appeared to be in good condition. As shown in Fig. 3, in all cases, it was the gap end of the insert that was missing. A study of these areas indicated that the missing sections of insert could be attributed to both the erosion and the high temperatures of the blow-by gases. Very little carbon was found in the cylinder exhaust ports and the cylinder walls and piston heads were exceptionally clean.

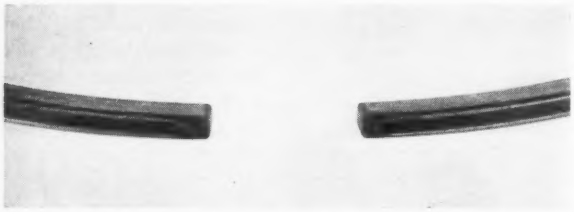


Fig. 3. Polytetrafluoroethylene Insert Compression Ring Showing Section of Insert Missing Adjacent to the End Gap

In view of these results, as shown in Fig. 4, a change was made in the design of the ring terminating the PTFE-glass insert approximately 1⅛ inch from the end gap as a means of reducing the erosion and temperature effects of the blow-by gases on the portion of insert adjacent to the end gap.

Full Scale Production Tests at 365 rpm

All of the data given in this paper were obtained in full-scale engine tests carried out under 24 hours-a-day and 7 days-a-week production conditions.

Fig. 4. The Improved Compression Ring With the Polytetrafluoroethylene Insert Terminating 1⅛ Inch From the Ring Gap

The results obtained with the first design of the compression ring with the PTFE-glass laminate insert (see Fig. 2) are summarized in Fig. 5. The ring gap wear data are the averages from a full set of 44 of these rings which were installed in an eleven-cylinder engine operating at 365 rpm. The crankcase oil consumption in this engine was 4.90 gallons per day. This consumption was considered normal for these engines. The cylinder bore measurements are averages taken from four of the cylinders at five positions in the cylinder. These positions were as follows:

1. Vertical cylinder bore 4 inches from head
2. Horizontal cylinder bore 4 inches from head
3. Cylinder bore at No. 2 exhaust port bridge
4. Cylinder bore at No. 3 (center) exhaust port bridge
5. Cylinder bore at No. 4 exhaust port bridge.

For comparative purposes, data from a typical engine equipped with standard compression rings and operating with normal upper cylinder lubrication are also included in Fig. 5. By comparing the two sets of data, it can be seen that results obtained with the experimental ring when the upper cylinder lubricators were completely shut off, compare favorably with the results obtained with the standard rings and normal upper lubrication. In addition, after 12,645 hours' operation with the experimental rings, very little carbon was found in the cylinder exhaust ports and the cylinder walls and piston heads were clean.

Full Scale Production Tests at 400 rpm

The ring and cylinder wear rate has been extremely low in the engines operating at 365 rpm using the standard compression rings and upper cylinder forced-feed lubrication. However, when the engines are operated at 390 to 400 rpm, the ring wear rate has been found to be somewhat higher than when the engines are operated at 365 rpm.

One of the twelve cylinder engines was equipped with a complete set of 48 improved experimental compression rings which has the insert terminating 1⅛

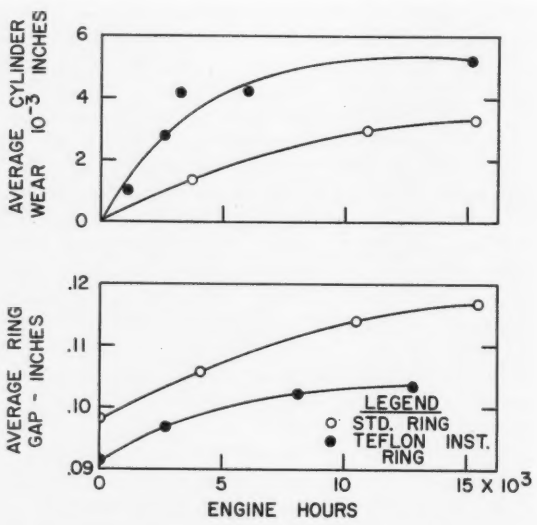


Fig. 5. Ring Gap and Cylinder Wear in Engines Operating at 365 rpm

inch from the ring gap as shown in Fig. 4. The engine was placed in operation at 400 rpm with the upper cylinder forced-feed lubricators completely shut off. The crankcase oil consumption in this engine was 6.52 gallons per day. The results of this test after 10,669 hours' operation are given in Fig. 6. For comparative purposes, data for a typical engine operating at 400 rpm with standard compression rings and upper cylinder forced-feed lubrication are included. As can be seen, the average increase in the end gap for the compression rings with PTFE-glass laminate inserts was of the same order as experienced with the standard rings and upper cylinder forced-feed lubrication. After 10,669 hours' operation, the average ring-to-land clearance wear of the experimental rings, based on the measurements made with a feeler gauge on sixteen rings on four pistons, was 0.0025 inches as compared to 0.0015 inches experienced with the standard rings and upper cylinder forced-feed lubrication after 13,969 hours' operation. The cylinder bore measurements were taken at the same positions as in the case of 365 rpm tests.

A statistical analysis of the data obtained in these tests disclosed that the standard deviation for the average ring gap wear was 0.017 inches and the standard deviation for the average cylinder wear was 0.0024 inches. This indicates that the wear rate for the experimental rings without any additional upper cylinder lubrication, and the wear rate for the standard rings with upper cylinder lubrication, is of the same order.

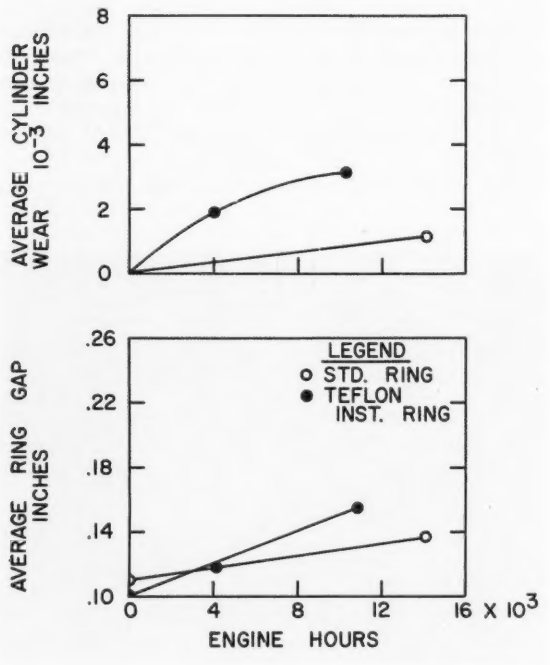


Fig. 6. Ring Gap and Cylinder Wear in Engines Operating at 400 rpm

SUMMARY

In summary, full-scale engine tests have been carried out under 24 hours-a-day and 7-days-a-week production conditions to evaluate the merits of cast iron compression rings containing PTFE-glass laminate inserts without any additional upper cylinder lubrication. These tests have been carried out in both eleven-cylinder and twelve-cylinder radial gas engines for about five years.

The results of the test indicate that the engines will operate successfully when equipped with experimental compression rings and when the upper cylinder forced-feed lubricators are completely shut off. The ring and cylinder wear in the tests carried out with the engines operating at 365 rpm were of the same order as obtained with the standard compression rings and upper cylinder forced-feed lubrication. In addition, with the use of the experimental rings, there is a definite advantage over the standard rings in that very little carbon builds up in the cylinder exhaust ports, and this factor can result in a considerable savings in man hours in the yearly maintenance of the egines.

Although a somewhat higher rate of ring wear was experienced with the experimental rings in the engine operating at 400 rpm than at 365 rpm, the wear was of the same order as that experienced with the standard rings and the upper cylinder forced-feed lubricators.

The experimental compression ring of the latest design which has the PTFE-glass insert terminating 1⅛ inch from the ring gap, as shown in Fig. 4, has been approved as the standard replacement compression ring for the eleven-cylinder engines when the major portion of the rings need replaced. A complete set of the rings are installed and the lubricant flow to the upper cylinders is completely shut off. The ring tests in the twelve-cylinder units will be continued a while longer.

ACKNOWLEDGEMENT

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Centralized Re-Circulating Coolant Systems for Cold Rolling Operations in the Steel and Aluminum Industries

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Three major requirements of roll oils for cold rolling metals are: (a) lubrication of strip during rolling (b) staining tendency during rolling or annealing (c) separation and recovery operation. These and many other requirements are placed on the roll oils for various types of cold rolling operations, and these requirements vary with the different types of metal, the reduction, and finish desired. The varying requirements on the roll oil also greatly affect the type of equipment being used to apply the coolant to the strip and rolls, also the type oil used will dictate which of the various recovery methods should be employed to keep the coolant as near its original condition as possible.

This paper will outline some of the basic types of coolant systems being employed in the industry today, pointing out the different design involved for processing metals such as aluminum, brass, and various types of steel such as silicon, stainless, etc. It is estimated that the production of aluminum foil per year would reach 300 million pounds by the end of 1960. The stepped up activity in this and other fields, along with the desire to roll faster and with improved surface finish has placed an added responsibility on the central coolant systems.

In recent years various new developments, especially in the field of filtration and clarification of coolants have been satisfactorily employed. These will be discussed along with their various advantages.

The primary function of the coolant system for cold rolling is to lubricate and cool both the strip and the rolls. The fluid used in the rolling operation must therefore have properties to serve this dual purpose. Many metals are being processed in cold rolling operations including carbon, stainless and silicon steels, brass, aluminum, titanium, copper, phosphor bronze, silver, nickel silver, tin, magnesium, and numerous alloys. For each of these operations the coolant suppliers and also those responsible for production have a particular type of oil or oil substitutes that they feel is best suited for each individual type of metal.

Straight mineral oils (with some additives) having a viscosity range of 32 to 100 SSU at 100F are used quite extensively for aluminum sheet and foil, and metals such as stainless steel, copper and brass which require a high surface finish. Although the term "cold rolling" is used, temperatures of the strip may rise to about 300F due to the rolling action, which is a combination of rolling to reduce thickness and slipping to improve surface finish. High flash and fire points of these oils are necessary to minimize the danger of fire.

Although straight mineral oils have good lubricating characteristics and minimize staining, they do not have the cooling advantages of many soluble oil emulsions. Soluble oil emulsions ranging from 3 to 20 per cent soluble oil in water are often used. These may contain mineral oils, palm oils, and various quantities of some emulsifiers or special soluble oils. These oils are used in cold rolling such products as silicon steel and stainless steel, and in hot rolling aluminum.

Palm oil, palm oil substitutes and mineral oils are often used where large quantities of pure water are flooded on the strip and rolls for cooling purposes, and

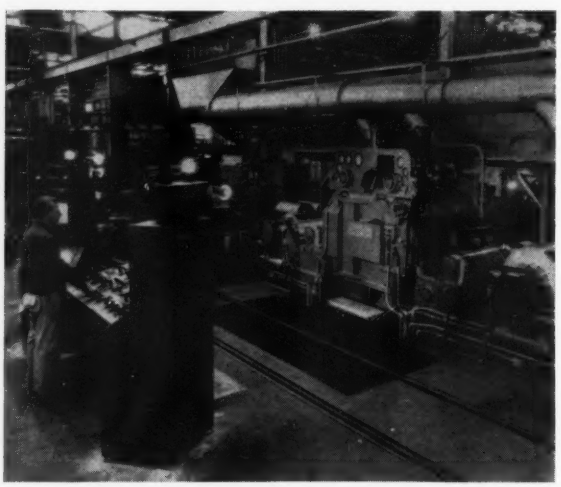

Fig. 1. Cold rolling strip on Sendzimir Mill. On this type of installation the coolant system must cool and lubricate the rolls and strip and also provide lubrication for the mill bearings.

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the oils are sprayed separately. In high speed tandem mills oils can also be mixed with water and agitated until applied.

The variety of coolants used by industry require highly specialized equipment to properly process the coolant, keeping it as near its original condition as possible and supplying it at proper temperatures, free of contamination, to the mill.

FACTORS AFFECTING THE SIZE OF THE SYSTEM

After determining the type of coolant that will be used, the system is designed so that it will remove the heat developed in the rolling operation so that excessive temperatures will not develop to harm the strip, rolls, or lubricating qualities of the coolant. The size of the coolant system is determined in gallons per minute and is a function of the product being rolled, the mill horsepower, the specific heat of the coolant, the amount of reduction being made, and the speed of the mill. In most instances, cooling water passing through a heat exchanger is used to keep the coolant at the desired operating temperature. In some instances, due to lack of sufficient cooling water, it is necessary to reduce the temperature by use of air cooled heat exchangers. If large quantities of cooling water are available, it can easily be seen that the coolant circulating capacity can be smaller in size. However, if cooling water is not available in large amounts at a low temperature (80 to 85F), then this is compensated by using a larger coolant system and narrowing the cooling range or duty on the heat exchangers. These varying factors that affect the size of the system are mentioned to illustrate the fact that the system must be especially designed for each particular application. Thus, two identical mills located in different parts of the country could have different size coolant systems.

THE COOLANT STORAGE RESERVOIR

Unlike the lubricating oil reservoir, the coolant reservoir has been developed in a variety of designs. The reservoir must be large enough to provide sufficient quantity of coolant for proper operation of the system and to permit large particles of contamination to settle to the bottom of the reservoir before being pumped out to the system again. In order to provide this settling time, many coolant reservoirs are designed with a capacity of from 15,000 to 20,000 gallons. On systems ranging between 1000 and 3000 GPM and using soluble oil and water, the settling time varies between 10 and 15 minutes. Oils often require up to 30 minutes due to higher viscosity. The resting time also permits water to settle in oil coolants to be drawn off and centrifuged. In soluble oil and water systems resting time dissipates foaming and permits tramp oil to rise to the top where it can be skimmed.

Where a high degree of contamination is removed from the stock being rolled, it is best to divide the reservoir into two compartments, one for the dirty oil returning from the mill and one for clean filtered oil. The dirty oil is pumped from its compartment through roughing filters, thence to the clean oil side of the tank. The clean oil passes through polishing filters on the way to the mill. The types of filters used are discussed later.

For ease of cleaning, the bottom of the reservoir should slope toward the front where filtering or purification connections are located so that the bulk of the contamination will settle at a point from which it can be readily removed. Large sections of the top are usually removable for the cleaning operation. Success has also been achieved by fabricating the coolant reservoirs with all of the stiffening members located outside, giving a clean, smooth surface over the interior of the reservoir. Plate type heating coils are frequently used in coolant reservoirs because of their light weight and compact size, and the fact that they are easy to remove.

Trash baskets are necessary to catch larger objects that find their way into the coolant return line. These baskets, which have a ¼ inch to ½ inch mesh lining, are placed at the return nozzle of the reservoir. On foil mills where pieces of foil fall into the mill pan and return to the coolant reservoir, it is advantageous to have larger screening areas because foil will coat the screen and block the flow. Some foil mill coolant tanks have been designed with as much as 75 per cent of the top formed of perforated steel plate lined with ¼ inch mesh screening.

Many other features—automatic temperature control, oil level indicators, high and low level float switches actuating alarms, floating suctions, dust-tight covers, and cleanout hatches—are all to be given consideration in designing a coolant reservoir that will require minimum attention and maintenance.

THE MAIN PUMPS

Most coolants are in the low viscosity range (150 SSU at 100F and lower), so that it is usually economical to employ centrifugal pumps to supply coolant to the mill. One or two main pumps supply sufficient quantities, with an identical pump as a standby. To obtain a constant volume of coolant at the mill, it is necessary to install a pump governor at the discharge of the main supply pumps. The governor is employed to main-

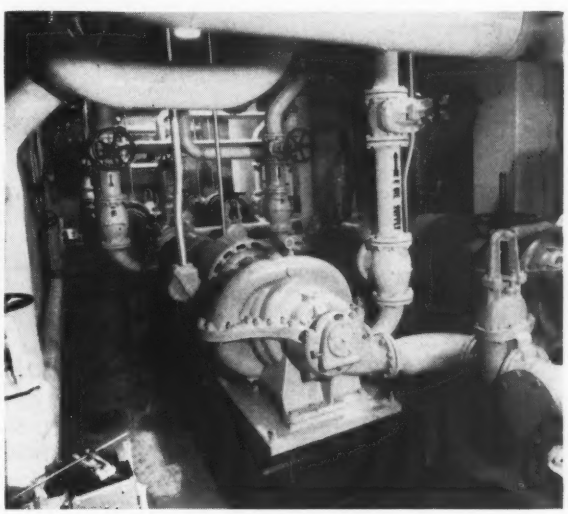

Fig. 2. General view of main pumping area on a centralized recirculating coolant system.

tain a constant discharge pressure at the pumps so that the centrifugal pumps will not increase in capacity at lower pressures, thus throwing the system out of balance and causing an excessive discharge of coolant at the mill.

In some installations a shutoff valve is located at the mill to stop the flow of coolant during changes of the strip or rolls. With the pumps running against the dead shutoff, it is advisable to bleed not less than 3% or more than 10% of the discharge back to the main coolant reservoir to eliminate the danger of overheating the coolant in the pumps. This method of relieving the coolant has been found superior to using relief valves because most relief valves that would be closed at the normal operating pressure require an opening pressure higher than the shutoff pressure of the pump. It is advantageous to use a three-way, two-port diverting valve at the mill to "dump" the coolant directly to the mill pan when it is not needed at the mill. This permits the coolant system to continue normal operation whether or not oil is being supplied at the mill.

THE FILTERS

A coolant system can only be as effective as its filters. As the desire for highly finished sheet and faster production continues to increase, additional importance is placed on this portion of the system.

In the past, many installations have relied mainly on the coolant storage reservoir to settle out foreign particles. However, expensive maintenance costs and down time are encountered in cleaning these large reservoirs. Some examples of settling times required for particles in still water are shown in Table 1; naturally, the settling times in oil would be even greater.

TABLE 1

VELOCITIES AT WHICH PARTICLES OF SAND AND SILT SUBSIDE IN STILL WATER

DIAMETER OF PARTICLE MM	ORDER OF MAGNITUDE	TIME REQUIRED TO SETTLE 1 FT.
10.0	gravel	0.3 seconds
1.0		3.0 seconds
0.5		6.0 seconds
0.4	coarse sand	
0.2		14.5 seconds
0.15		38.0 seconds
0.05		1.8 minutes
0.04	fine sand	
0.015		33.0 minutes
0.005		2.2 hours
0.004	silt	
0.0015		35.0 hours

An examination of this table shows that it would be impossible to rely primarily on this method to remove smaller, lightweight particles.

The full flow replaceable cartridge-type filter, where the entire flow of oil must pass through the filter, is probably the most widely used filter in the industry. Its popularity is undoubtedly due to its low initial cost and simplicity of design; however, consideration should be given to cost of operation, including the cost of these replacement cartridges and the number of man hours required to change them. Types of cartridges include resin impregnated wool fibers, cellulose, pleated paper, laminated cellulose disks, fullers earth, and diatomaceous earth.

Naturally, in selecting the proper filter, it is most economical to size the filter so that it does not remove particles smaller than necessary from the coolant. For example, on a soluble oil and water system for hot rolling aluminum, or for cold rolling steel without a highly finished surface, it is possible to use an automatically-cleaned mechanical filter. This removes particles down to .005 inch and, because the cartridge is cleaned continuously, the necessity of changing cartridges is eliminated. In such systems where a finer degree degree of filtration is required, it is still possible to use the automatic filter as a roughing filter to remove the larger particles, and install a cartridge filter on the full flow to the mill to remove particles as small as five microns. By both roughing and polishing filters, the bulk of the large contamination is removed by the roughing filter, thus lengthening the time between cartridge changes.

In mineral oil systems it is necessary to control the ash content of the oil. This job, of course, falls upon the filters. In the cold rolling of steel and brass, where small amounts of oxides are produced, the ash content of the oil can, in most cases, be held at a tolerable level by cartridge type filters filtering from 20 to 5 microns. In the cold rolling of aluminum sheet and foil, however, the specifications often call for an ash content as low as 0.005%, which may be lower than the original ash content of the oil. For most aluminum rolling operations, with the exception of hot rolling which is done with soluble oil and water, it is necessary to use a bypass filter with cartridges packed with fullers earth to adsorb oxidation products and suspended solids small enough to pass through full flow filters. This will control the ash content and color of the oil.

Flow through the bypass filter ranges from 15 to 25% of the total oil being supplied to the mills rolling

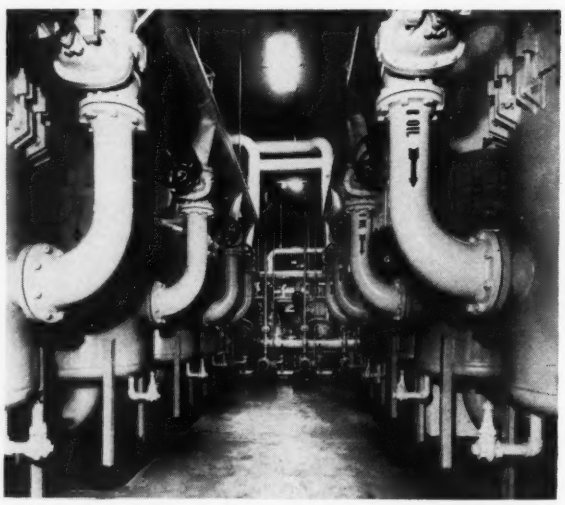

Fig. 3. Full flow filtration area of dual coolant system which supplies mineral oil or soluble oil and water to the mill for rolling different types of metal.

material such as brass, stainless steel and aluminum sheet or strip. Bypass fullers earth filtration will be from 25 to 50% of the total flow when rolling aluminum foil. This is due to the fact that aluminum foil is rolled at high speeds and an extremely low solids content is desired to eliminate imperfections or pinholes in foil which may be only 0.00025 inch thick.

During the operation of the mineral oil type coolant system, a constant check should be made to determine the ash and additive content of the oil. The fullers earth filter removes additives in the oil as well as ash, although the percentage of additives adsorbed is lower than that of ash adsorbed. When the fullers earth is spent, the cartridges must be changed and replaced with new factory-packed cartridges or bulk refill type cartridges.

THE NEW AUTOMATIC FULLERS EARTH/DIATOMACEOUS EARTH FILTER

Where a high degree of clarity is desired in the oil system, it has been possible to incorporate a recently developed automatic diatomaceous and fullers earth filter. This filter operates on the precoat principle, using monel filter tubes with openings of .005 inch which are precoated with diatomaceous earth to filter contamination down to ½ micron. After the diatomaceous earth has automatically precoated the filter tubes, the system oil is permitted to pass through the filter and back to the reservoir. With the automatic diatomaceous/fullers earth type of filter, it is possible —and actually preferable—to filter 110% of the oil that is being supplied to the mill. The oil reservoir is divided into two sections separated by an overflow baffle. The oil from the mill flows into the prefiltered section, then to the diatomaceous earth filler, then back to the clean oil section of the reservoir. Because the oil is being filtered at a greater rate than it is being supplied to the mill, a flow of coolant continually cassades from the filtered section of the reservoir over the baffle into the prefiltered area.

During the filtering operation on mineral oil systems, fullers earth mixed with the diatomaceous earth is fed from a body feed tank to the filter so that both color and ash content can be controlled. A dial can be set to maintain the proper ash desired according to laboratory tests made during operation of the filter.

At the end of each filter run, which may be indicated by a pressure drop across the filter cake or a shutdown of the mill, the filter cake and oil is blown down into a drain tank beside the filter. The filter itself is then clean and ready to go back into service immediately after a maximum shutdown time of 15 minutes. A recovery filter cleans and returns the blowdown oil to the filter system. The sludge is removed from the recovery filter after it has been air blown into a completely dry condition. This entire operation is automatic, and an operator is required only to fill the precoat and body feed tanks and empty the recovery filter. The manual attention required in a normal filtering day is 15 minutes.

This type of filter is now being used extensively in aluminum cold rolling operations; in addition, it is now being tested for use in filtering soluble oil and water for coolant systems on hot aluminum mills.

AUTOMATIC OPERATION

In a modern coolant system it is desirable to have it operate automatically. One can be termed completely automatic when the operator can push a start button on the mill's control panel to send the desired flow of coolant to the mill at the proper temperature and pressure. Automatic temperature control of the central coolant reservoir and the heat exchanger is an absolute necessity. In some installations a recording type temperature control is located within view of the operator so that he has a visual indication of the temperature of the oil in the reservoir, the amount of cooling done by the heat exchanger, and the temperature of the coolant supplied to the mill. Some rolling operations require two heat exchangers—one for heating the oil above the normal operating temperature to warm up the mill, or to provide a higher temperature for special passes through the mill, the other to cool the oil during normal operation.

It is important to have devices warning of such conditions as high or low level in the coolant reservoir, high differential pressure across the filters, and low oil pressure at the pump discharge.

Prior to installation of a coolant system on a new or existing mill, serious thought should be given to the new and more advanced types of equipment now available. Advanced engineering of the system, with thorough examination of original equipment maintenance and operational costs, is necessary to insure the reliable installation of a Centralized Re-Circulating Coolant System.

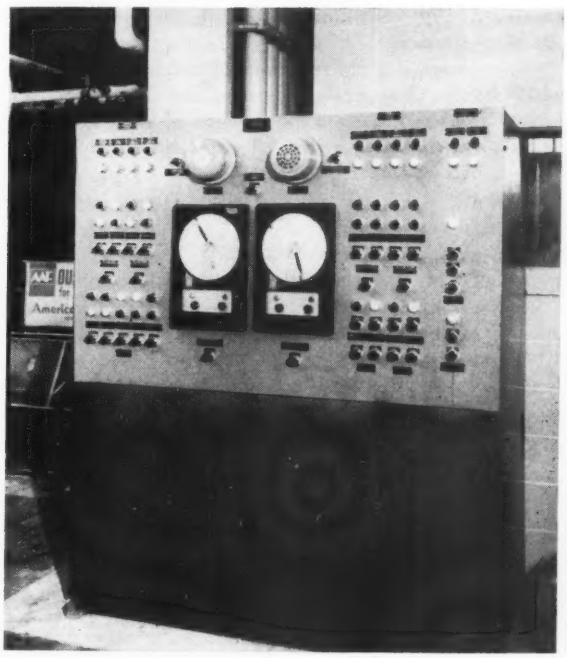

Fig. 4. Control panel for coolant system located on mill floor within view of the mill operators.

Controlling the Spoilage of Water Soluble Cutting Fluids

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This is a presentation of work performed over a period of years in both the laboratory and the field. It provides information of academic value for those studying this complex problem. It also contains material of a practical nature which may be used for controlling spoilage of emulsions used in metal cutting.

Sporovibrio desulfuricans, a particular type of sulfate-reducing anaerobic bacteria, was found to be highly responsible for spoilage in most cases. This micro-organism is described. Its sources as well as environmental conditions favoring its propagation are also discussed.

An important electrochemical action is described which has not been directly associated with bacterial action before. It causes the release of molecular hydrogen which has a powerful catalytic effect on the growth of anaerobic bacteria.

THE PROBLEM

For many years the development of spoilage in soluble oil emulsions, which are used in metal cutting operations, has been a matter of deep concern. This situation is annoying because machine operators refuse to work with the foul-smelling coolants. Time is lost while the machine is cleaned, disinfected, and a new coolant installed.

EVIDENCE OF SPOILAGE

The characteristics of spoiled emulsions are:

1. Color change from a milky white to a blue or blue-gray
2. Development of offensive odors
3. In extreme cases, inversion or instability of emulsion
4. Decreased rust prevention properties

Presented at the 14th ASLE Annual Meeting, Buffalo, New York, April, 1959

This paper concerns both laboratory and field experience pertaining to the control of spoilage of soluble oil emulsions. While it is not presented as a final solution to this very complex problem, it is hoped that the information will be of value from both an academic and a practical standpoint. This information corroborates and supplements the findings of other investigators.

The main points that will be covered are:

1. The basic causes of spoilage
2. Description of an important bacterium
3. Laboratory Evaluations
4. Environmental factors affecting spoilage
5. A case history
6. Methods for controlling spoilage

CONDITIONS FAVORING SPOILAGE

Field experience has indicated that the conditions most favorable to spoilage are an almost complete absence of oxygen in the emulsion, low pH and the presence of metallic cuttings or fines in the system. Moderately elevated temperatures (80-100F) and the absence of light often accelerate deterioration.

Emulsions develop offensive odors most frequently following plant shutdowns. Spoilage is more prevalent in machines having individual coolant reservoirs and those which are used on a periodic basis. In both cases the emulsion is in a state of quiescence and has little contact with air. Oil film on the surface of the coolant also creates an anaerobic condition.

Plant managers are often of the opinion that the components in the soluble oil are the principal cause of spoilage. In one case where spoilage cropped up after many years of satisfactory service, the customer felt that inferior raw materials had been substituted. The causes are usually of an entirely different nature.

ROLE OF BACTERIA

Examination of foul smelling emulsions has invariably shown the presence of large numbers of bacteria. While it is impossible to exclude these, certain practices can be observed which will keep their population down to a point where they are innocuous. One species which was found to be very important in this action will be described. It was an anaerobe described as Sporovibrio desulfuricans (later referred to as Sd). It was present in substantial quantities in every spoiled emulsion gathered from the field. It was also present in the great majority of laboratory tests involving spoilage.

Type of Bacteria Responsible

Generally, the charts, curves, etc., express bacterial contamination only in terms of the total bacterial count and the presence of Sd. The total count includes all living organisms, aerobic and anaerobic. Aerobic bacteria require ready access to air, whereas anaerobes cannot grow in the presence of atmospheric oxygen. In only one case was an effort made to identify the aerobes.

It is acknowledged that spoilage may be caused by bacteria other than Sd. Other investigators (1) (2) have shown that "putrid odors" may develop as a result of the action of Pseudomonas oleovorans, Pseudomonas putrifaciens and Achromobactor.

Although anaerobes are customarily found and are believed to be the predominating cause of spoilage, the example given below indicates another type of organism which was contributory.

In a laboratory grinder test described in this paper, one case of spoilage was caused by a sulfate reducing aerobe, which was identified as an atypical proteus. Hydrogen sulfide was the predominating odor but there was also the odor of mercaptans.

In this connection it is pointed out that a spoiled emulsion is seldom a health hazard. None of the bacteria which various investigators have found to make an essential contribution to the odor problem are pathogenic to man. However, a spoiled emulsion may indicate poor sanitary conditions in a plant such as would result from expectorating into the coolant. In such a case the emulsion may carry other bacteria which are harmful, such as the colon type.

While the methods described in this paper are particularly effective in dealing with spoilage caused by the anaerobe mentioned, they are believed beneficial in cases caused by other bacteria.

Description of Sporovibrio desulfuricans

Fig. 1 is a photomicrograph of a culture of this organism. It is primarily a comma-shaped organism, but the vegetative form may vary somewhat in size and shape depending on environmental conditions. These fluctuations, however, do not alter their characteristics for reducing compounds to hydrogen sulfide.

Sporovibrio desulfuricans is an anaerobe (does not require oxygen for growth), an autotrophe (synthesizes its food from inorganic salts), and a spore former.

In the spore form they are highly resistant to heat and bactericides. The spore may be dormant for as long as 50 years awaiting favorable conditions for changing to a vegetative cell. Only the vegetative cell causes spoilage.

The more favorable temperature for growth is between about 80 and 100F. Below 65F their growth is severely restricted, and above 160F they can exist only in the spore form.

Sporovibrio desulfuricans will reduce sulfates, thiosulfates, bisulfites and under some circumstances sulfonates, to hydrogen sulfide. Because of this, they are commonly called sulfate-reducers. They have a great affinity for sulfur and will utilize it in practically any form, reducing it to hydrogen sulfide.

Source of Anaerobes

Sporovibrio desulfuricans come from the soil. They may get into the emulsion in the following ways:

1. Water—The water used for making the emulsions may come from rivers, lakes or wells. Deep wells are known to be rich in anaerobes.
2. Dirt—This may be brought in from the storage yard on steel stocks. It may also be blown, dropped or swept into the coolant reservoir. Dirty containers used in preparing the emulsion will also contribute.

The soluble oils used for the emulsion very rarely carry these bacteria.

ROLE OF ELECTROCHEMICAL ACTION

Bacterial action is preponderantly the cause of spoilage where foul odors are concerned. However, there is another factor which is seldom related to the problem. That is the effect of the electrochemical action between the iron fines in the system and the emulsion.

Electrochemical action usually precedes bacterial growth and can greatly accelerate it. This action alone can produce color change in an emulsion. However, hydrogen sulfide odors will accompany this action only in cases of abnormally high emulsion temperatures (130 to 210F).

Electrochemical action is of importance because it causes the release of molecular hydrogen which is an excellent source of energy for the anaerobes. This speeds their growth enormously.

A condensed version of the electrochemical action is shown in Fig. 2 and Fig 2A. It is offered as an explanation for the blue color which usually forms in the bottom of the coolant sump where the chips are in intimate contact with the emulsion. It also suggests a mechanism for releasing the hydrogen.

Equations [1], [2] and [3] show the production of hydrogen which is utilized by sulfate reducers. Equations [4] and [5] show the production of hydrogen sulfide which in turn reacts with the ferrous ions

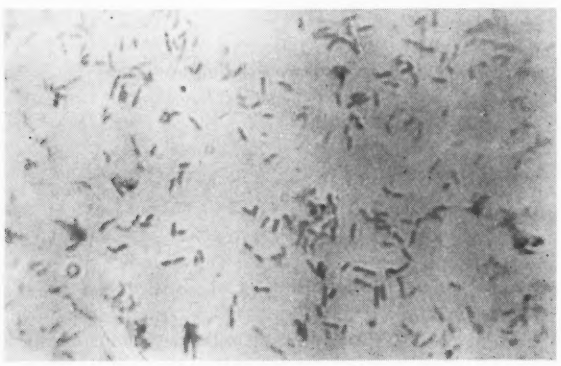

Fig. 1. Sporovibrio Desulfuricans Bacteria

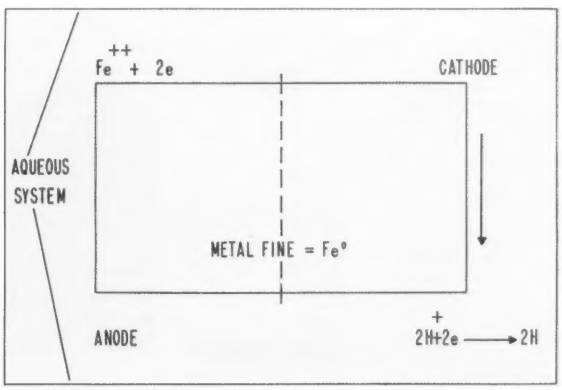

Fig. 2. Diagram Showing Electrochemical Action

$$Fe^{\circ} \rightleftharpoons Fe^{++} + 2e \quad \text{(ANODIC REACTION)} \qquad [1]$$

$$2H^{+} + 2e \rightleftharpoons 2H \quad \text{(CATHODIC REACTION)} \qquad [2]$$

OR

$$Fe^{\circ} + 2H^{+} \rightleftharpoons Fe^{++} + H_2 \uparrow \qquad [3]$$

$$4H_2 + Na_2SO_4 \rightleftharpoons H_2S \uparrow + 2\,Na\,OH + 2\,HOH \qquad [4]$$

$$Fe^{++} + H_2S \longrightarrow FeS \downarrow + 2H^{+} \qquad [5]$$

Fig. 2A. Equations for Electrochemical Action

present to produce a colloidal ferrous sulfide solution which is blue. Theoretically, these equations could explain any odor formation in a soluble oil emulsion, except that for every molecule of hydrogen sulfide generated there will be ferrous ions to precipitate ferrous sulfide. Therefore, no excess hydrogen sulfide would be released into the atmosphere to form an odor.

From these equations, it appears that the blue color in the emulsion can be caused by electrochemical reaction but that the hydrogen sulfide forming the offensive odor is from bacterial action.

LABORATORY EVALUATIONS

In order to perform laboratory tests it was first necessary to develop a strain of Sporovibrio desulfuricans which could be used for inoculation. This was done in a specially constructed bacteriological laboratory. The Sd strain was developed from a spoiled emulsion obtained from the field.

In early tests the importance of iron fines in developing bacterial growth and hence spoilage was established. This is illustrated in Fig. 3.

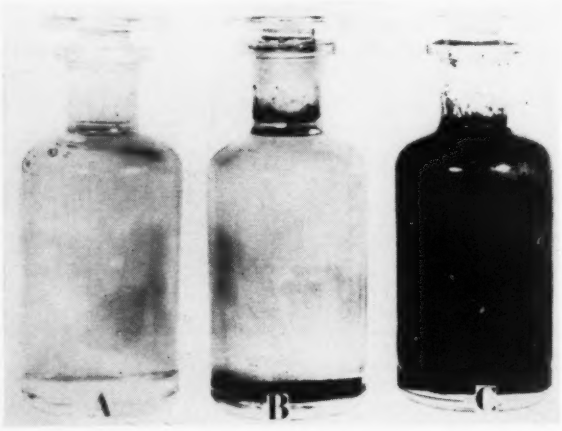

Fig. 3. Effect of Iron Fines on Bacterial Growth

These bottles (60 ml) were all filled with Van Delden's solution, an inorganic medium used for the cultivation of anaerobic bacteria.

Bottle A contained only the test solution
B contained test solution plus Sd inoculum
C contained test solution plus Sd inoculum plus cast iron fines

Bottles B and C received the same amount of inoculum (30,000 Sd). Bottle C was the only one containing iron fines (20 gms). Bottle C showed considerably more precipitated iron sulfide than Bottle B. The actual bacterial count (anaerobes) of Bottle C was 50 times that of Bottle B. Another bottle set up similar to Bottle C but with no inoculum gave the same clear appearance as Bottle A.

Test Methods

Before discussing the factors found to have the most prominent effect on spoilage, a description of the two test methods is given. These tests were run in a grinder and in bottles. Correlation between the two tests was found to be good.

In some of the following tables it may be noted that the total bacteria found does not always correlate directly with the inception of spoilage. This may be due to some variation in the proportion of Sd making up the total count. Only qualitative determinations were made for Sd.

1. Grinder Test (Fig. 4)

Full scale tests were run by grinding metal under field conditions. Steel was ground for two full days using an inoculated emulsion and then left in a dormant condition to observe spoilage. Table 1 gives the test conditions and Fig. 4 shows the grinding machine.

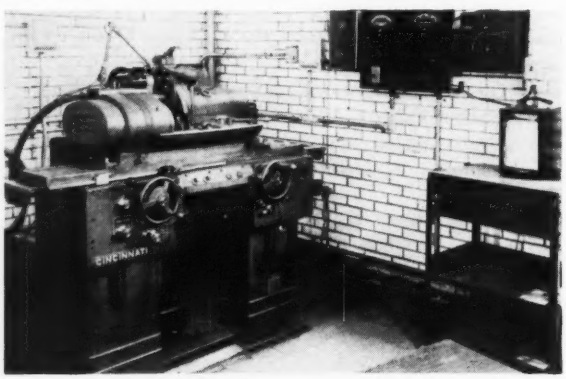

Fig. 4. Laboratory Grinding Machine

TABLE 1—CONDITIONS FOR THE GRINDER TEST

Emulsion Used—20 gals. (1-20) conventional anionic type
Type Grinder—4 inch Cylindrical Grinder
Metal Ground—SAE X1335 Steel (Sulfur = 0.1%)
Grinding Time—2 days—idle thereafter
Inoculation—50 ml Sporovibrio-desulfuricans strain at start of test
Spoilage Criterion—Blue color or foul odor

2. Bottle Test (Fig. 5)

This test was used because it was more economical to run with regard to both time and facilities. Table 2 lists the conditions.

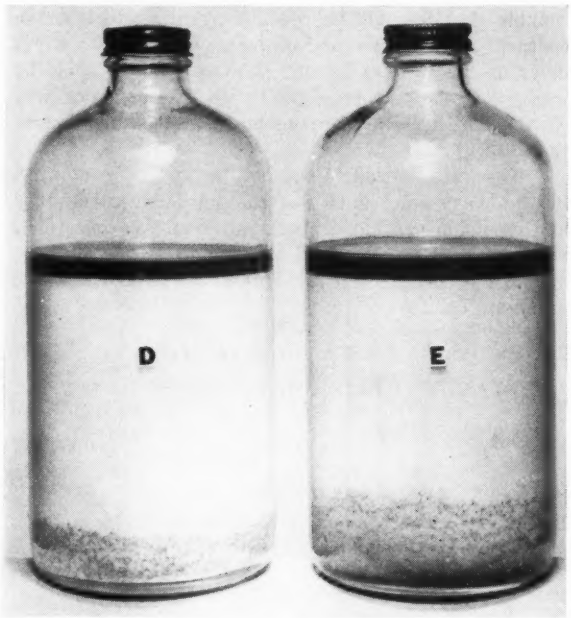

Fig. 5. Bottle Test for Emulsion Spoilage

TABLE 2—CONDITIONS FOR THE BOTTLE TEST

Container—1 Quart glass bottle
Emulsion—600 ml of 1-20 dilution (conventional anionic type)
Metallic Fines—200 gms SAE X1335 (Sulfur = 0.1%)
Temperature — Ambient (unless noted otherwise) (75-82F)
Anaerobic Condition—Emulsion covered ½ in. mineral oil
Inoculation—5 ml Sporovibrio desulfuricans strain (300,000 organisms per ml)
Spoilage Criterion—Complete bluing of emulsion or hydrogen sulfide odor (Bottle E)

FACTORS AFFECTING SPOILAGE

1. Iron Fines

One of the most important factors in spoilage was the contact between the iron fines produced during machining, and the emulsion. The sulfur content of the fines was also influential.

Concentration of Fines

In both grinder and bottle tests, where no fines were present the test emulsion remained sweet indefinitely (90 days +). However, the greater the concentration of fines in the emulsion the more rapid the spoilage. These data are shown in Table 3.

TABLE 3—EFFECT OF IRON FINES IN GRINDER TEST

CONCENTRATION OF FINES WT. %	BACTERIAL COUNT TOTAL, MILLIONS	SD	SPOILAGE INCEPTION, DAYS
20	13	Present	5
10	12	Present	10
5	8	Present	16
0	4	Present	90+

Effect of the Sulfur Content of Iron Fines

All laboratory data clearly indicated the important effect of the sulfur content of the steel being ground. Studies of spoilage were hampered for quite a period because spoilage experienced in the field could not be produced in the laboratory. It was not until the importance of the sulfur content of steel fines was established that correlative work could be carried on.

The data from the grinder test (Table 4) showed that when the sulfur content was 0.01% no spoilage occurred. With fines containing 0.1% sulfur the emulsion lasted only 5 days. It is of interest to note that in the case of the low sulfur steel no Sd were detected.

Table 5 gives the results of bottle tests conducted in a different manner than those previously described. They were run at a higher temperature (210F) and were not inoculated with Sd. The information is of academic value only because the temperature of an emulsion in service seldom gets over 120F. The data are of interest because in addition to showing the effect of the sulfur content of the fines, they illustrate that both discoloration and hydrogen sulfide formation can occur in emulsions heated far beyond the temperatures used in industry.

TABLE 4—EFFECT OF SULFUR CONTENT OF FINES IN GRINDER TEST

	SULFUR CONTENT OF STEEL BEING GROUND					
	0.01%			0.10%		
TEST FLUID	BACTERIAL COUNT TOTAL, MILLIONS	SD	SPOILAGE INCEPTION, DAYS	BACTERIAL COUNT TOTAL, MILLIONS	SD	SPOILAGE INCEPTION, DAYS
Emulsion (1-20) Conventional Soluble Oil	20	None	40 +	12	Present	5

TABLE 5—EFFECT OF SULFUR CONTENT OF FINES IN BOTTLE TESTS

White Emulsion (1-15) Temperature 210F
Metal: emulsion ratio = 1:1 Time 24 Hrs.

Sulfur Content			
0.01%		0.10%	
Emulsion Color	Hydrogen Sulfide	Emulsion Color	Hydrogen Sulfide
White	None	Blue	Present

2. Effect of Sulfur Content of Soluble Oils

Emulsions made from two soluble oils were tested by the bottle method. Both soluble oils were of similar composition except that one contained an additional material, sulfurized fat. Part of the sulfur in the latter material was loosely combined and in that state affected spoilage most markedly. The product containing the sulfurized fat spoiled in half the time required for the unsulfurized one.

3. Effect of pH of Emulsion

Test results (Table 6) showed that control of the pH of the emulsion was the most effective means of controlling spoilage.

When the pH was in the range of 7 to 9 the tendency toward bacterial decomposition was high. In the range of 9 to 9.5 it was greatly reduced and above 9.5 it did not occur. Sporovibrio desulfuricans were not found to exist above the latter value.

This suggests buffering as a method of controlling the pH. Actually this was done in the grinder test where the pH was held above 9.6.

4. *Effect of Bactericides*

While this is one of the simplest ways of extending emulsion life, no bactericide was found which would give protection indefinitely, without periodic additions. In many field experiences it has been revealed that bactericides lose their effectiveness with use. In some cases the bacteria were believed to have developed immunity. Periodic changes in the type of bactericide, or the use of multiple bactericides frequently improves performance. There are newly developed materials which are much more effective than those used in these experiments. However, detrimental side effects often limit their use. Some bactericides were incompatible with the soluble oil. Others were toxic to human beings or caused skin irritation. One very effective bactericide caused severe disintegration of the metal being machined.

In the bottle tests the use of a good bactericide extended the life of the emulsion from 8 to 40 days or five-fold.

5. Effect of Isolation of Fines

Since spoilage is strongly affected by the interaction between the fines and emulsion, it seemed reasonable that it could be reduced by minimizing their contact. A novel method proved very successful. A layer of heavy oil (Specific Gravity greater than 1) was put in the bottom of the bottle. The emulsion was then added, followed by the fines. The emulsion was then inoculated.

The fines settled to the bottom and were covered by the heavy oil. The lack of contact between the fines and emulsion prevented spoilage because it interfered with both electrochemical and bacterial action. No spoilage occurred even at a pH of 7. The results are given in Table 7.

TABLE 7—EFFECT OF ISOLATED FINES IN BOTTLE TESTS

		BACTERIAL COUNT		SPOILAGE
ISOLATION	PH RANGE	TOTAL, MILLIONS	SD	INCEPTION, DAYS
None	9.3-8.6	5.30	Present	8
Yes	7.8-6.8	0.25	None	120 (none)

6. Effect of Aeration

Since anaerobes do not survive in the presence of generous quantities of oxygen, it is obvious that periodic or continued aeration will prevent their growth. During a 30 day test in the grinder no odor developed during the week, providing the coolant was circulated 15 minutes a day. Hydrogen sulfide forming in the emulsion over the week end could be dispelled by circulating for one hour.

CASE HISTORY OF A FIELD PROBLEM

One machine shop, after years of satisfactory service with a conventional soluble oil containing no bactericide, suddenly found themselves with a bad spoilage problem. It spread from some drill presses to lathes, grinders, etc.

Investigation showed that a group of war surplus drill presses had been recently installed. Their individual coolant reservoirs had not been cleaned out in years. Anaerobic conditions were perfect. The machines were filled with fresh emulsion which soon turned blue and became very foul smelling. The con-

TABLE 6—EFFECT OF EMULSION PH

TYPE TEST	PH RANGE	BACTERIAL COUNT TOTAL, MILLIONS	SD	SPOILAGE INCEPTION, DAYS
Grinder	9.3 - 9.0	12.00	Present	5
	10.0 - 9.6	25.00	—	No Spoilage (60 days +)
Bottle Tests	8.9 - 6.8	.02	Present	1
	9.3 - 8.6	5.00	Present	8
	10.3 - 9.9	None	None	None (120 days)

dition spread to other machines because the pails used for removing the spoiled emulsions were also used for charging soluble oils to non-contaminated machines.

Two drill presses were set aside for a study. Both were originally badly contaminated with a gelatinous formation in their sumps which was a result of anaerobic infestation. The following treatments were given to the machines.

Machine No. 1

(a) Spoiled emulsion discarded.
(b) Coolant system cleaned by circulating fresh water. Final water fairly clean.
(c) Fresh emulsion (no bactericide) charged.

Machine No. 2

(a) Spoiled emulsion removed.
(b) All accessible surfaces cleaned by brushing.
(c) Hot water was circulated in successive charges until the water was clear.
(d) Hot water (150F) containing a commercial disinfectant was circulated for 20 minutes.
(e) The disinfecting solution was removed.
(f) Filled with an emulsion of the same soluble oil as used in Machine 1 but containing a specific bactericide.

Both of these machines were continued in service for two months. During this time samples were taken for bacterial analysis and laboratory inspection.

The resultant bacterial counts are shown on Fig. 6. The curves show that in the case of Machine No. 1 the bacteria multiplied very rapidly and in ten days the emulsion was blue and foul smelling. On the other hand, the emulsion in Machine No. 2 containing the bactericide, was continued in service for two months without spoiling. In fact, this plant never complained of spoilage following this experience.

Fig. 6 is interesting because it shows that spoilage occurred when the living anaerobic population (vegetative) was somewhere around a million organisms. Furthermore, a life cycle is indicated. The rapid death rate is not clearly understood but may be a result of lack of food or the accumulation of metabolic products.

No discussion has been directed to the significance of the aerobic population since they were not as important in this case as the anaerobes. However, they may have had some effect.

The previous discussion is of value also because it describes a method for dealing with an existing spoilage problem.

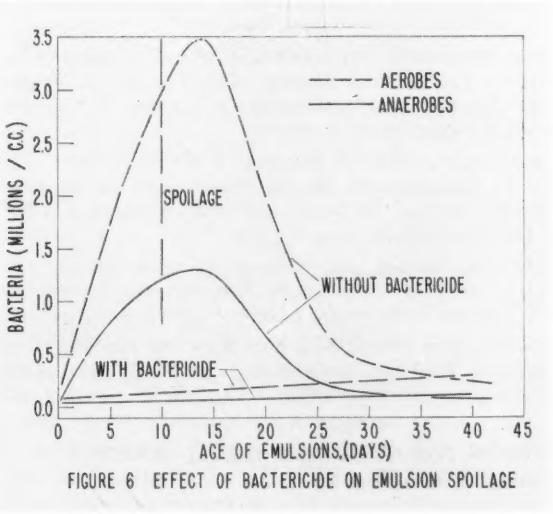

FIGURE 6 EFFECT OF BACTERICIDE ON EMULSION SPOILAGE

Fig. 6. Effect of Bactericide on Emulsion Spoilage

SUMMARY

1. Bacterial action is the predominating cause of spoilage
2. Electrochemical action may accelerate bacterial growth
3. Sporovibrio desulfuricans, an anaerobe, is a strong contributing factor in spoilage
4. Spoilage may be prevented by
   A) Maintaining the emulsion pH above 9.6
   B) Isolation of the fines from the emulsion
5. Spoilage may be controlled by
   A) Good housekeeping and plant sanitation
   B) Use of a good bactericide
   C) Maintaining pH of emulsion between 9.0 and 9.5 (Buffering)
   D) Avoidance of anaerobic conditions (Oil Blanket, etc.)
   E) Prompt removal of metal cuttings
   F) Periodic aeration
   G) Use of soft water for emulsion (low sulfates)
   H) Periodic sterilization (160 to 180F)
   I) Use of low sulfur metals
   J) Minimize the use of sulfurized soluble oils
   K) Refrigeration of coolant to 65F.

ACKNOWLEDGMENT

The contributions of the following people in this investigation are acknowledged: R. T. Edwards, M. J. Janes, E. Laug, E. P. Wilkinson and J. J. Bell.

REFERENCES

1. Lee, M. and Chandler, A. C., "A Study of the Nature, Growth and Control of Bacteria in Cutting Compounds." *J. Bacterial*, 1941, pp. 373-386.
2. Lindert, A. W., "Some Problems Encountered in the Use of Soluble Oils." *Lubrication Engineering*, Vol. 7, No. 5, 1951.

The information contained in this report is based on a careful laboratory investigation and we believe the conclusions reflect a logical analysis of the data studied. However, all conclusions and recommendations are stated without any warranty or guarantee since we are not in a position to know or evaluate all of the conditions under which the information may be used in industrial practice or otherwise. Socony Mobil Oil Company, Incorporated, therefore disclaims any liability for losses or claims arising out of the use of any material in this report. Furthermore, nothing contained in this report should be construed as recommendation to use any product in such a way as to infringe any existing patents.

Program for the 1960 ASLE-ASME Joint Lubrication Conference

to be held in Boston at Statler-Hilton Hotel

October 17, 18, 19, 1960

Monday, October 17, 1960

SESSION I: SURFACE FILMS IN LUBRICATION
Parlors A-B-C—10:00 a.m.

Chairman: J. H. Schulman, Columbia University, New York City.
Vice Chairman: I. M. Feng, Ethel Corp., Detroit, Michigan.

"Absorption of Polar Organic Molecules on Machined Metal Surfaces and Properties of the Resulting Surface Films," by H. A. Smith and R. L. Bennett, University of Tennessee, Knoxville, Tenn. *(ASME Paper No. 60-LUB-4)*

"Lubrication at High Temperatures with Vapor Deposited Surface Coatings," by D. J. Baldwin and G. W. Rowe, Tube Investments Research Laboratories, Cambridge, England. *(ASME Paper No. 60-LUB-4)*

"Inhibiting Corrosive Wear in Lubrication with Halogenated Gasses at 1500 F by Use of Competitive Reactions and Other Methods," by D. H. Buckley and R. L. Johnson, N.A.S.A., Lewis Research Center, Cleveland, Ohio. *(ASLE Paper No. 60LC-1)*

SESSION II: GEAR LUBRICATION
Parlors A-B-C—2:00 p.m.

Chairman: L. J. Collins, General Electric Co., Lynn, Mass.
Vice Chairman: V. S. Wagner, DeLaval Steam Turbine Co., Trenton, New Jersey.

"Instantaneous Coefficients of Gear Tooth Friction," by G. H. Benedict and B. W. Kelley, Caterpillar Tractor Co., Peoria, Illinois. *(ASLE Paper No. 60LC-2)*

"Experiences with Scuffing-Tests on Gear Oils in Back to Back Rigs," by G. Niemann, H. Rettig, and G. Lechner, Technische Hochschule München, West Germany. *(ASLE Paper No. 60LC-3)*

"Gear and Bearing Lubrication in Extreme Environments with Polyphenyl Ethers," by J. B. Accinelli, V. N. Borsoff, W. W. Kerlin, and S. J. Beaubien, Shell Development Co., Emeryville, Calif. *(ASME Paper No. 60-LUB-8)*

"The Volume of Stressed Material Involved in the Rolling of a Ball," by R. C. Drutowski, Research Laboratories, General Motors Corp., Warren, Michigan. *(ASME Paper No. 60-LUB-7)*

SOCIAL HOUR 5:30—7:30 p.m.
Complimentary Refreshments

Tuesday, October 18, 1960
SESSION III-A: UNUSUAL ENVIRONMENTS
Ball Room Assembly—9:00 a.m.

Chairman: H. E. Mahncke, SKF Industries, Philadelphia, Penn.
Vice Chairman: M. B. Peterson, General Electric Co., Schenectady, New York.

"Evaluation of Ball Bearing Separator Materials Operating Submerged in Cryogenic Liquids," by W. A. Wilson, K. B. Martin, J. A. Brennan, and B. W. Birmingham, Cryogenic Engineering Laboratory, National Bureau of Standards, Boulder, Colo. *(ASLE Paper No. 60LC-4)*

"The Performance of Ball Bearings in Nitrogen and Carbon Dioxide at Elevated Temperatures," by K. G. Eickhoff and A. White, United Kingdom Atomic Energy Authority, Chester, England. *(ASLE Paper No. 60LC-5)*

"The Behavior of Lubricating Oils in Inert Gas Atmospheres," by A. Beerbower and D. F. Greene, Esso Research and Engineering Co., Linden, New Jersey. *(ASLE Paper No. 60LC-6)*

SESSION III-B: FLUID FILM JOURNAL BEARINGS
Parlors B-C—9:00 a.m.

Chairman: D. F. Hays, General Motors Technical Center, Detroit, Michigan.
Vice Chairman: J. M. Gruber, Waukesha Bearing Co., Waukesha, Wisconsin.

"Solution of Reynolds Equation for Arbitrarily Loaded Journal Bearings," by O. Pinkus, General Electric Co., Lynn, Mass. *(ASME Paper No. 60-LUB-3)*

"Orthogonally Displaced Bearings, I," by D. F. Wilcock, General Electric Co., Pittsfield, Mass. *(ASLE Paper No. 60LC-7)*

"Grease Lubrication Studies with Plain Journal Bearings," L. J. Bradford, E. M. Barber, and J. R. Muenger, Texaco Research Center, Beacon, New York. *(ASME Paper No. 60-LUB-5)*

SESSION IV-A: FRICTION AND WEAR
Ball Room Assembly—2:00 p.m.

Chairman: W. E. Campbell, Consulting Chemist, Cleveland, Ohio
Vice Chairman: M. E. Merchant, The Cincinnati Milling Machine Co., Cincinnati, Ohio

"The Effect of Lubricant Viscosity and Composition on Engine Friction and Bearing Wear," by E. H. Okrent, Esso Research and Engineering Co., Linden, New Jersey. *(ASLE Paper No. 60LC-8)*

"Friction and Wear of Metals in Gases up to 600°C," by D. F. Cornelius and W. H. Roberts, United Kingdom Atomic Energy Authority, Chester, England. *(ASLE Paper No. 60LC-9)*

"Metallic Contact and Friction Between Sliding Surfaces," by M. J. Furey, Esso Research and Engineering Co., Linden, New Jersey. *(ASLE Paper No. 60LC-10)*

"Development of Iron-Base Seal Materials for High Temperature Rubbing Applications," by R. J. MacDonald, Clevite Corp., Cleveland, Ohio. *(ASLE Paper No. 60LC-11)*

SESSION IV-B: FLUID FILM THRUST BEARINGS
Parlors B-C—2:00 p.m.

Chairman: O. Pinkus, General Electric Co., Lynn, Mass.
Vice Chairman: A. A. Raimondi, Westinghouse Research Laboratories, Pittsburgh, Pennsylvania.

"The Effect of The Method of Compensation on Hydrostatic Bearing Stiffness," by S. B. Malanoski and A. M. Loeb, The Franklin Institute, Philadelphia, Pennsylvania. *(ASME Paper No. 60-LUB-)*

"Performance of Elastic, Centrally Pivoted, Sector, Thrust Bearing Pads—Part I," by B. Sternlicht, J. C. Reid, Jr.* and E. B. Arwas, General Electric Co., Schenectady, New York, and *Bureau of Ships, Washington, D.C. *(ASME Paper No. 60-LUB-10)*

"Transient Lubrication of an Accelerated Infinite Slider Bearing," by F. A. Lyman and E. A. Saibel, Rensselaer Polytechnic Institute, Troy, New York. *(ASLE Paper No. 60LC-12)*

Wednesday, October 19, 1960

SESSION V: HYDRODYNAMIC GAS BEARINGS
Ball Room—9:00 a.m.

Chairman: W. A. Gross, IBM Research Laboratory, San Jose, California
Vice Chairman: A. M. Loeb, The Franklin Institute, Philadelphia, Penn.

"An Improved Analytical Solution for Self-Acting Gas-Lubricated Journal Bearings of Finite Length," by J. S. Ausman, Autonetics, Inc., Downey, California. *(ASME Paper No. 60-LUB-9)*

"An Assessment of the Value of Theory in Predicting Gas Bearing Performance," by S. Cooper, Rolls-Royce, Limited, Derby, England. *(ASME Paper No. 60-LUB-2)*

"A Novel Form of Self-Acting Gas Lubricated Thrust Bearing," by A. Nahavandi and F. Osterle, Carnegie Institute of Technology, Pittsburgh, Pennsylvania. *(ASLE Paper No. 60LC-13)*

"Considerations on the Starting of Gas Lubricated Bearings," by M. Wildman, Autonetics, Inc., Downey, California. *(ASME Paper No. 60-LUB-11)*

"A Numerical Solution for the Finite Gas Lubricated Full Journal Bearing," by A. A. Raimondi, Westinghouse Research Laboratories, Pittsburgh, Pennsylvania. *(ASLE Paper No. 60LC-14)*

SESSION VI: HYDROSTATIC GAS BEARINGS
Ball Room—2:00 p.m.

Chairman: H. G. Elrod, Columbia University, New York City.
Vice Chairman: A. M. Loeb, The Franklin Institute, Philadelphia, Penn.

"Pressurized Journal Gas Bearings," by J. H. Laub, Jet Propulsion Laboratory, Pasadena, California. *(ASLE Paper No. 60LC-15)*

"Externally Pressurized Spherical Gas Bearings," by J. H. Laub, and R. H. Norton, Jet Propulsion Laboratory, Pasadena, California. *(ASLE Paper No. 60LC-16)*

"A Theoretical Investigation of Pressure Depression in Externally Pressurized Gas-Lubricated Circular Thrust Bearings," by H. Mori, Mass. Institute of Technology, Cambridge, Massachusetts. *(ASME Paper No. 60-LUB-6)*

"The Performance of Externally Pressurized Bearings Using Simple Orifice Restrictions," by D. S. Allen, P. J. Stokes, and S. Whitley, United Kingdom Atomic Energy Authority, Chester, England. *(ASLE Paper No. 60LC-17)*

"Extension of the Conducting Sheet Analogy to Externally Pressurized Gas Bearings," L. Licht, The Franklin Institute, Philadelphia, Pennsylvania. *(ASME Paper No. 60-LUB-1)*

ABSTRACTS OF ASLE PAPERS TO BE PRESENTED AT THE 1960 JOINT LUBRICATION CONFERENCE

INHIBITING CORROSIVE WEAR IN LUBRICATION WITH HALOGENATED GASES AT 1500F BY USE OF COMPETITIVE REACTIONS AND OTHER METHODS, by Donald H. Buckley and Robert L. Johnson, 60LC-1

Various gases were used as corrosion inhibitors for nickel- and cobalt-base alloys in halogen-containing gas lubrication systems. Corrosion experiments were conducted at 1500F with CF_2Cl_2 and various mixtures of the gas with inhibitors. One gas found to be a satisfactory inhibitor was air (oxygen). Oxygen reacted at the metal surface in competition with chlorine of CF_2Cl_2, thus reducing corrosion. Friction and wear experiments conducted with CF_2Cl_2-air mixture lubricating Al_2O_3 sliding on cobalt base alloy showed low wear and low friction over the temperature range from 75 to 1500F.

INSTANTANEOUS COEFFICIENTS OF GEAR TOOTH FRICTION, by G. H. Benedict and B. W. Kelley, 60LC-2

In a gear contact as simulated on a roller test machine, the instantaneous coefficient of friction follows the concept of transition from boundary to hydrodynamic lubrication. The coefficient has been found to increase with increasing load and to decrease with increasing sum velocity, sliding velocity and oil viscosity as each of these quanties is varied individually. The viscosity was determined by the temperature of the oil-entering contact and the viscosity-temperature characteristics of the lubricant. The results have been combined in a formula which closely represents the data. When this formula is used in gear scoring calculations, the same type of U-shaped load-speed curve is obtained as has been found of several gear test rigs.

EXPERIENCES WITH SCUFFING-TESTS ON GEAR OILS IN BACK TO BACK RIGS, by G. Niemann, H. Rettig, and G. Lechner, 60LC-3

Abstract not available at time of publication.

EVALUATION OF BALL BEARING SEPARATOR MATERIALS OPERATING SUBMERGED IN LIQUID NITROGEN, by W. A. Wilson, K. B. Martin, J. A. Brenman, and B. W. Birmingham, 60LC-4

The demand for the reliable operation of rotating machinery in cryogenic applications has resulted in a continuing program directed toward determining the life and durability of ball bearings operating at cryogenic temperatures. On the basis of past work in this field, it was determined that the ball separator, when made from conventional materials, usually was the cause of failure. A program of screening separator materials with bearings subjected to actual operating conditions was undertaken. A number of different separator materials and arrangements were tested to determine their relative durability. The apparatus used provided a method of loading the bearing axially

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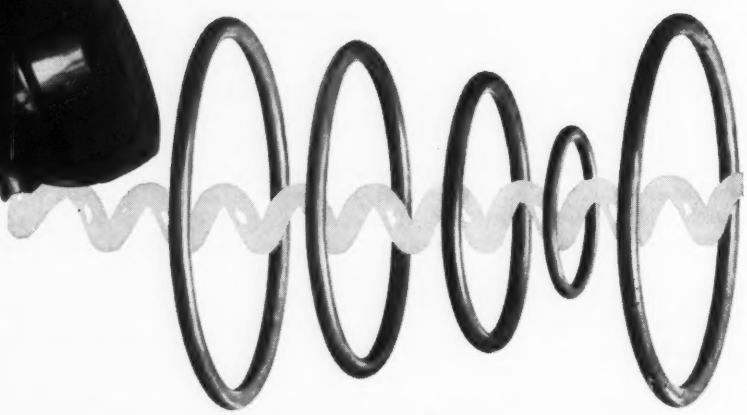

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(Continued from page 421)
and included a means of measuring bearing torque, wear and load during operation. All of the tests of this screening program were conducted using liquid nitrogen. The results are presented in the form of bearing life, progressive bearing torque and progressive bearing wear for the various configuratene and types of separator materials tested. Photographs showing the test apparatus and some test bearings are included in addition to a graphic presentation of the test results. This test program proved that a ball separator made from filled Polytetrafluoroethylene material is superior to the other separator materials tested in liquid nitrogen.

THE PERFORMANCE OF BALL BEARINGS IN NITROGEN AND CARBON DIOXIDE AT ELEVATED TEMPERATURES, by K. G. Eickhoff and A. White, 60LC-5

Life tests on ball bearings running at 100 rpm without lubrication in hot gaseous environments under thrust loads show that their performance, worse than when running under lubricated conditions, is significantly affected by the environment. Two gases, nitrogen and carbon dioxide, are considered. In nitrogen, at temperatures of 200C and 250C, the load-carrying capacity was only some 2% of the capacity for lubricated operation at normal temperature, the best results being obtained with full type, cageless, angular contact bearings. In carbon dioxide, however, at 325C and 375C, loads of up to 30% of the lubricated capacity were achieved with deep groove, caged bearings. Similar bearings in a 16% Cr stainless steel performed even better at up to 50% of the lubricated capacity.

Unlike the fatigue failures encountered under lubricated conditions, these bearing failures were by wear. The measured wear is analyzed and related to the shape of the load-life curve. It is postulated that, in carbon dioxide, bearings acquire a "lubricating" film of oxide which accounts for their better performance in this environment. Treatment with molybdenum disulphide had no beneficial effect under these conditions.

THE BEHAVIOR OF LUBRICATING OILS IN INERT GAS ATMOSPHERES, by A. Beerbower and D. F. Greene, 60LC-6

The interactions of five gases (helium, hydrogen, nitrogen, argon and carbon dioxide) with mineral and synthetic lubricating oils were studied. The interactions examined included gas solubility, foaming, entrainment, evaporation of oil into gas, stability of oil in presence of gas, and effect of dissolved gas on oil viscosity. Several of the gases showed behavior (appreciably different from that of air) that was not predicted by conventional theories. No important differences were found between mineral and synthetic (diester) oils in these respects. The additives used can have appreciable influence on the foaming and entrainment characteristics, and evaporation rates, of both types of oils.

ORTHOGONALLY DISPLACED BEARINGS, I, by Donald F. Wilcock, 60LC-7

Journal Bearings with cross-sections consisting of circular arcs with centers displaced from the geometric bearing center along the mid-radius of the arc or lobe have been in use for many years. Examples are the "elliptical" bearing and the "three-lobe" bearing, the advantage sought being increased stability under light loads without the reduced oil flow accompanying a reduced clearance ratio.

This paper is directed toward the apparently neglected possibility of displacing the lobe centers of two-lobe bearings orthogonally with respect to the mid-radius of the lobe. Analysis shows that when this displacement is in a direction opposite to the shaft surface motion, and the bearing is centrally loaded, shaft stiffness orthogenal to the load vector is substantially increased. At the same time, vertical stiffness remains essentially unchanged, as does minimum film thickness, while oil flow is increased. The analysis was carried out for a bearing having in cross section two arcs each subtending an angle of 150°, an L/D ratio of ½, and with the arc centers each displaced from the geometric center by half the radial clearance.

THE EFFECT OF LUBRICANT VISCOSITY AND COMPOSITION ON ENGINE FRICTION AND BEARING WEAR, by E. H. Okrent, 60LC-8

This paper investigates the effect of lubricant composition on engine friction and connecting-rod gearing wear. Special attention has been given to polymer-thickened (VI improved) oils since these oils are characterized by shear-dependent viscosity and a simultaneous occurrence of viscous and elastic properties. The variables investigated in this study included lubricant viscosity, polymer type and concentration.

Two sets of engine studies were conducted, one to determine engine friction, the other to measure connecting-rod bearing wear, using irradiated bearings. For Newtonian fluids, the engine friction and wear response can be predicted from classical lubrication theory—that is (a) friction decreases with increasing viscosity until a viscosity is reached where friction is a minimum. Beyond this viscosity, further increases in viscosity result in increased friction (b) bearing wear decreases with increasing viscosity, but as a step function, not linearly and the transition viscosity (of the step) corresponds to the viscosity which gives a minimum engine friction.

The addition of polymeric VI improvers (non-Newtonian fluids) to mineral oil base stocks reduces engine friction and lowers bearing wear—the amount of friction and wear reduction depending on the polymer type and concentration. This paper demonstrates that polymer-thickened oils actually give better bearing wear performance than their comparable mineral oil counterparts despite the fact that they have a lower apparent viscosity at high rates of shear. In addition, it appears that temporary viscosity loss is not the sole cause of the reduced engine friction of polymer-thickened oils.

FRICTION AND WEAR OF METALS IN GASES UP TO 600 C, by D. F. Cornelius and W. H. Roberts, 60LC-9

Apparatus is described for measuring friction and wear in controlled atmospheres. A comparison is made of the room-temperature behavior of copper, mild-

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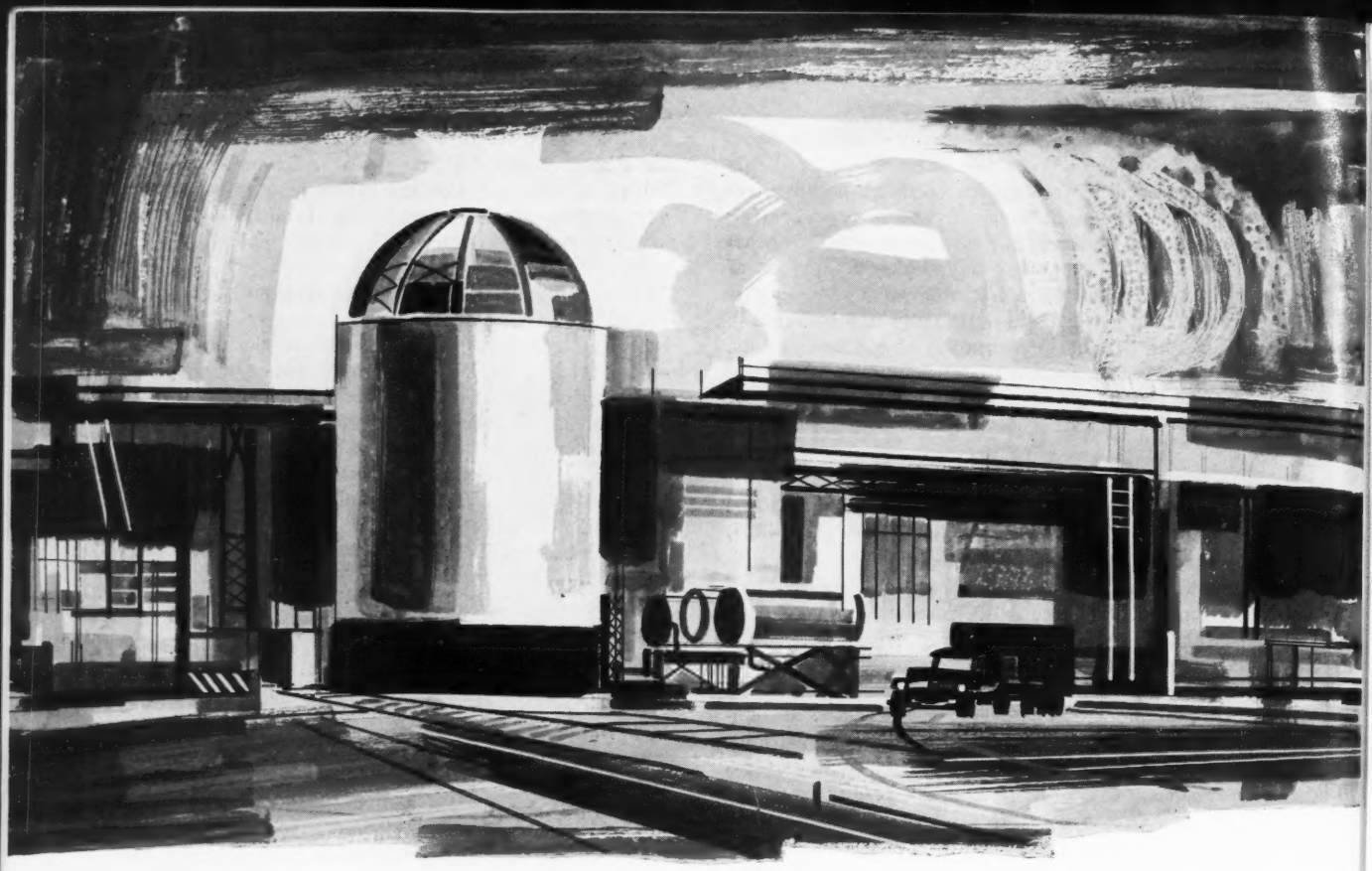

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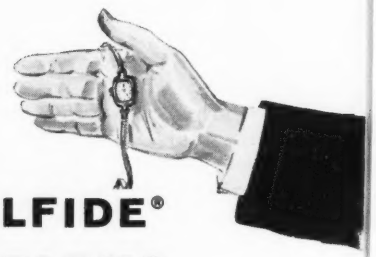

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(Continued from page 423)
steel and brass, rubbed against a hardened tool steel, in four environments—vacuum (10^{-3} mm Hg), dry helium, dry carbon dioxide and dry air. The effect of varying the water-vapour content in air is also discussed.

The initial selection of rubbing pairs for service at elevated temperatures in gaseous environments under unlubricated conditions, is based on their long-term resistance to corrosion and their ability to give low wear rates. In general, therefore, the materials must be hard. Several alloys having chromium contents of between 1% and 30%, and hardness values in the range 200-1000 VPN have been investigated. These included two low-chromium nitrided steels, a tungsten-chromium tool steel and a series of four Co-Cr-W alloys. Specific wear rates and friction coefficients varied markedly with temperature, and values in the ranges 10^{-13} — 10^{-8} om^3/om kg and 0.1–0.8, respectively, were obtained in both dry carbon dioxide and dry-helium. Lowest wear rates were observed with the nitrided steels. The diverse characteristics observed are discussed on the basis of current theories of adhesive wear.

METALLIC CONTACT AND FRICTION BETWEEN SLIDING SURFACES, by M. J. Furey, 60LC-10

A new device has been developed and used to study metallic contact and friction between sliding, lubricated surfaces. The system consists basically of a fixed metal ball loaded against a rotating cylinder. The extent of metallic contact is determined by measuring both the instantaneous and average electrical resistance between the two surfaces. Friction between the ball and cylinder is recorded simultaneously with contact.

In general, the electrical resistance was found to oscillate rapidly between an extremely low value and infinity, suggesting that metallic contact is discontinuous. The average resistance of an oil film is therefore a time-average, that is, a measure of the percent of the time that metallic contact occurs. The results indicate that metallic contact is much more prevalent than would have been expected from other published studies in which electrical resistance or discharge methods were employed.

Using this apparatus, the entire region from hydrodynamic (no metallic contact) to pure "boundary" lubrication (continuous metallic contact) can be readily investigated. Load, speed, mineral oil viscosity, the presence of additives and operating time were found to be important variables influencing metallic contact.

The apparatus is particularly useful in studying the action of antiwear and "extreme pressure" additives. It allows one to measure not only the effectiveness of these compounds in reducing metallic contact, but also the rate at which they act and the durability of protective films which may form.

DEVELOPMENT OF IRON-BASE SEAL MATERIALS FOR HIGH TEMPERATURE APPLICATIONS, by Robert J. MacDonald, 60LC-11

This paper describes an experimental investigation of materials for use as high-temperature rubbing seals. The results of a comprehensive evaluation of the rubbing properties of commercial high-speed tool steels are presented. It is shown that molybdenum steels have desirable high-temperature seal characteristics. Tungsten steels, on the other hand, exhibit inferior properties. The best overall performance is demonstrated by a steel containing both molybdenum and tungsten in combination with cobalt.

These commercial tool steels are not effective over 1000F therefore new material combinations were sought. Using powder-metallurgy techniques, a series of iron-base alloys containing molybdenum and cobalt were studied. It was found that alloys containing from 5 to 20 percent of both molybdenum and cobalt exhibit excellent rubbing properties up to 1200F and, in general, are superior to the tool steels tested.

Further testing of Fe-Mo-Co materials revealed that friction and wear are markedly dependent upon the test conditions. A minimum coefficient of friction was obtained with the highest surface speed (150 fps) and with the highest ambient temperature (1200F).

The desirable rubbing properties of this family of materials are explained in terms of surface oxidation products which act as solid-film lubricants during high-temperature rubbing.

TRANSIENT LUBRICATION OF AN ACCELERATED INFINITE SLIDER, by F. A. Lyman and E. A. Saibel, 60LC-12

An analytical solution is obtained for the transient pressure developed in a slider bearing without side leakage when one of the bearing surfaces is accelerated tangentially. The lubricant is assumed to be incompressible and to have constant viscosity, and the film thickness is assumed to remain fixed in time. Asymptotic solutions for small and large values of time are found to describe the transient pressure adequately and yield expressions for pressure and load-carrying capacity in closed form. The results show that the pressure rise is negligible until a certain time after the bearing begins to be accelerated, but afterwards the pressure approaches a steady state rapidly, and the total duration of the transient is quite short.

A NOVEL FORM OF SELF-ACTING GAS LUBRICATED THRUST BEARING, by Amir Nahavandi and Fletcher Osterle, 60LC-13

A non-pressurized parallel-surface gas lubricated thrust bearing is analyzed with the slider in steady spin and precession and found to develop a load capacity. The operation of this self-acting thrust bearing over a range of operating conditions is studied and the results applied to the so-called bevel bearing. The load capacity is obtained numerically by solving the Reynolds Equation for compressible lubricant in finite difference form on a high speed digital computer. It is found that this load capacity can be significant.

(Continued on page 427)

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(Continued from page 425)

A NUMERICAL SOLUTION FOR SELF-ACTING GAS LUBRICATED FULL JOURNAL BEARINGS OF FINITE LENGTH, by A. A. RAIMONDI, 60LC-14

Numerical solutions of Reynolds' equation pertaining to the finite length journal bearing with a constant uni-directional load and lubricated with a compressible fluid are given. Results are tabulated for the constant viscosity, isothermal case for L/D values of 2, 1 and ½ and design charts, applicable over the full range of the compressibility number ($\lambda = \mu U R/C^2 p_a$) are presented for eccentricity ratios ranging from 0.1 to 0.8. Differences between gas and liquid lubricated bearings are mentioned and the numerical techniques employed discussed in some detail. Use of the design charts is illustrated and the numerical results compared with an existing approximate analytical solution and some test results available in the literature.

PRESSURIZED JOURNAL GAS BEARINGS, by JOHN H. LAUB, 60LC-15

Externally pressurized gas-lubricated bearings with multiple orifice feed are investigated. An analytical treatment is developed for a semi-cylindrical bearing with 9 orifices and for a cylindrical journal bearing with 192 radial and 24 axial orifices.

Experiments are described on models of the two bearing configurations with specially designed fixtures which incorporate pneumatic loading and means for determining pressure profiles, gas flow and gap height. The correlation between theory and experiment is satisfactory.

EXTERNALLY PRESSURIZED SPHERICAL GAS BEARINGS, by John H. Laub and Robert H. Norton, Jr., 60LC-16

Spherical gas-lubricated bearings are of considerable interest in applications requiring a pivoting or rotating support with three degrees of freedom, for instance in attitude control simulators of space vehicles.

An analytical and experimental study of externally pressurized spherical gas bearings with orifice regulation is presented along with the experimental findings, which are in good agreement with the predictions of the viscous flow theory.

THE PERFORMANCE OF EXTERNALLY PRESSURIZED BEARINGS USING SIMPLE ORIFICE RESTRICTORS, by D. S. Allen, P. J. Stokes and S. Whitley, 60LC-17

The load capacity and vibration characteristics of externally pressurized thrust and journal bearings have been investigated. The bearings used orifices sufficiently recessed back from the bearing surface to ensure that the area of the orifice is the minimum presented to the gas flow. The journal bearings consist of plain cylinders with one or two rows of eight orifices, and the thrust plates of plain discs with six orifices drilled in equispaced circumferential grooves. The load capacity of the thrust plates agrees with that calculated but the vibrations are greater than predicted. The load capacity of journal bearings is about half that calculated assuming axial flow conditions in the bearing, but circumferential flow can account for the difference. Synchronous and half-speed vibrations of a shaft rotating within these bearings have been measured and found to agree with those calculated on the assumption that the gas films behave as linear springs.

Preprints of the above papers will be available at the Conference for those attending. They will also be available at the ASLE National Office for mail-orders after October 15, 1960.

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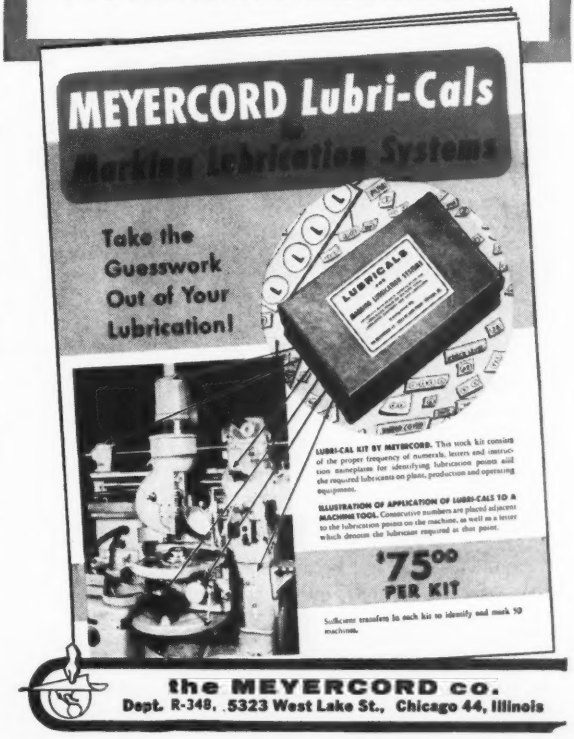
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Lubrication Abstracts

Edited by W. E. Campbell

Selected literature compiled by members of the Technical Committees and Industry Councils of the Society.

James W. Cole, Jr., "High Temperature Anti-oxidants for Synthetic Fluids," Report on Contract AF 18 (603) 103, Jan. 1959, 13 p. 15 refs. AFOSR-TN-59-149. U. S. Government Research Reports, v. 32, no. 5, 1959, 605

Evaluation of anti-oxidants for possible use at 400°F. and above in synthetic fluids is described. Synthesis of likely anti-oxidants related to phenothiazine and other promising types, and modes and mechanisms of anti-oxidant action at elevated temperatures are also described. These studies include evaluation of over 400 compounds in selected combinations with about 20 synthetic fluids. About 50 derivatives of phenothiazine, synthesized and characterized, were evaluated as anti-oxidants. The oxidation behavior of blended fluids in the presence of metals such as Cu, Ag, Mg, and alloys of Fe and Ti are reported. Atoms of N, S, and Se are important elements in anti-oxidants when located in strategic positions in the molecule. *(Abstractor: R. McKay)*

Carl Alex Fischer, "A Few Important Facts About Lubricants," *Wire & Wire Products*, v. 35, no. 2, 1960, 194.

Three general types of lubricants are discussed with specific examples cited. Dry lubricants, wet lubricants, pastes and greases are covered separately. Various metallic soaps are discussed with the limitations of each type. Oil viscosity should vary between 1000/1500 "Redwood 1" to 50 "Redwood 1" at 100°F for wire at 0.250" and 0.010" diameter, respectively. *(Abstractor: E. W. Emmerich)*

"Automatic Die Lubrication Improves Forging Quality," *Steel*, v. 145, no. 10, 1959, 101.

The increase in frequency of routine service operations makes equipment last longer. The application of an automatic die lubricator reduces reject and rework rates. The colloidal graphite and water lubricant is sprayed over the top die while the hot forging press is open. Previously, the press was lubricated by hand every ten strikes. Now, the top die is lubricated after every strike. *(Abstractor: R. McKay)*

Lucian J. Leta (L. Sonneborn and Sons, Inc.), "Field Test Depressants for Reversion," *Petroleum Refiner*, v. 37, no. 11, 1958, p. 273-4.

Results of a field test for determining the reversion tendencies of five base oils containing three pour point depressants are described. It is concluded from the data that ASTM Pour Point gives little indication of an oil's tendency towards Pour Point reversion under field conditions. Pour Point reversion may be induced by the addition of too much depressant. The lower the natural pour point of the oil, the less its tendency to revert. *(Abstractor: M. I. Smith)*

Staff Writer, "Tests Show That Rene 41 Can be Welded, Machined," *Steel*, v. 145, no. 25, 1959, 90.

Rene 41, a vacuum melted, nickel base alloy used in jet engine parts can be welded and machined. Tests show that special treatment is necessary for welding and shortened cutter life in machining. Speeds and feeds must be low. Several solvents were better for machining than conventional coolants. *(Abstractor: R. McKay)*

N. A. Scarlett (Shell Research Ltd., Thornton), "Greases to Prevent Fretting Corrosion," *Engineering*, v. 189, no. 4901, 1960, 424-5.

Of the many greases tested on an experimental rig, most displayed only poor or moderate anti-fretting properties; a few were excellent. The rig housing, in which the lubricated thrust bearings were mounted, was oscillated through an angle of 6 degrees at 1420 cycles per min. Tests were run continuously for 50 or 1,000 hr under 600 lb load and at room temp. Weight loss of the steel race, due to wear, was the criterion of the lubricants' effectiveness. A lithium-base grease contg. non-E.P. polar additives and a calcium-base grease contg. E.P. additives were satisfactory in preventing fretting corrosion. Several of the greases, which rated good on this rig, performed well in various field applications. The type of soap and oil did not appear to be major factors, reasonably good anti-fretting greases were found with a wide variety of gelling agents and with oils differing widely in viscosity and type. The indiscriminate use of molybdenum disulfide in greases for anti-fretting purposes is not advised, since these greases showed variable performance. In the one instance where graphite was added to a grease, the anti-fretting properties of the base grease were reduced. *(Abstract: Edward H. Loeser)*

(Continued on page 430)

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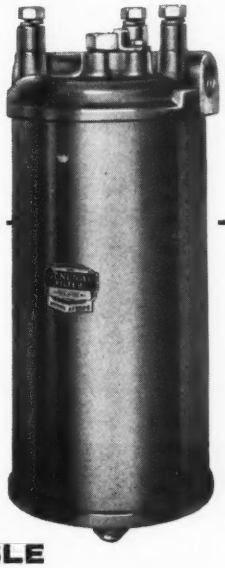

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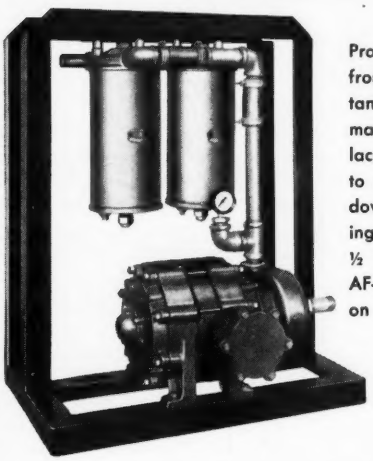

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ELEMENT	Wool Felt, Cleanable				Phenol Resin Pleated Paper	To Suit Application	100 Mesh (.005 opening) Monel*				
FILTRATION (MICRONS)	5	5 or 15	5	5 or 15	5, 15, 35	5, 15, 35 & larger	140	140	140	140	140
HEIGHT (IN.)	16 7/16	10 9/16	16 7/8	11 1/4	16 7/16	26Lx17W x32H	4 3/16	6 3/16	9 3/16	8 1/4	12 1/4
DIAMETER (IN.)	6 9/16	6 9/16	8 1/4	8 1/4	6 9/16	—	4 1/2	4 1/2	4 1/2	5 1/2	5 1/2
WEIGHT (LBS.)	26	18	36	29	26	150	2 1/4	2 1/2	3	4 1/2	5 1/4
INLET-OUTLET SIZE (IN.)	1 inch Pipe Thread						3/4	1	1 1/4	1 1/2	2

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LUBRICATION ABSTRACTS

(Continued from page 428)

P. A. Bennett, "A Look at the Effects of Lubricant Additives on Surfaces," SAE Paper No. 107B for Nov. 5-6, 1958 Meeting.

An interference microscope is used to study the surface roughness of engine cam follower feet as affected by a group of zinc dithiophosphate compounds in a reference engine oil. Both engine and bench tests are used to prepare several different types of followers for study. Conclusions are that the zinc dithiophosphate additives can form small scale roughness, that they vary in action with cam follower material, and that the performance of these additives appears dependent on rate of surface reaction and wear rate. The additive concentrations evaluated are proportional to the repression of scuffing but are not effective after scuffing was initiated. Thermal stability of the additives is a factor in their anti-scuff performance. *(Abstractor: George C. Lawrason)*

H. D. Lees (United Steamship Co., Copenhagen, Denmark), "Statistics on Cylinder Wear in Marine Diesel Engine," *Wear-Usure-Verschleiss* v. 2 no 4, May 1959, pp. 273-95.

A method of marine cylinder wear data analysis using punched cards and digital computers is described. Curves are shown for cylinder wear versus time considering the different parameters such as type of engine, make of engine, cylinder hardness, types of fuel, and operating conditions. Several hypotheses concerning causes of cylinder wear are given and ways to reduce wear are mentioned. Changing from heavy fuel to diesel oil one hour before shutdown combined with turning the engine during downtime while supplying lubricant has reduced wear. The effects of anticorrosive additive cylinder oils, cooling water temperature, cylinder wall temperature distribution and scavenging air temperature are discussed. A comparison of wear in normal, worn, and rebored cylinders is also made. *(Abstractor: George C. Lawrason)*

A. B. Vipper, E. P. Mosikhin and S. R. Belova, "Some Relationships in the Loss of Detergent Additives from Oil," Khim. i Tekhnol. Topliv i Masel, v. 4, no. 1, 1959, 59-63

The detergent additive content of a motor oil was found to decrease rapidly during the initial few hours of running in either a one-cylinder engine or in six-cylinder automotive engines. The rate of additive loss diminished with continued running, and in some instances, the additive content of the oil appeared to increase after extended running. These data are based on analyses of the oil for barium. Detergent removal was not due to oil filters since none were used. The authors' explanation follows. Initial loss is due to reaction of the additive with surfaces of the parts of the engine that are wetted by the oil. Since the loss of additive increased when the engine was operated in an oxygen-enriched atmosphere, it may be presumed that the effect of oxygen on the surfaces of engine parts is very significant. Results of absorption studies of the additive on metal powders and on carbon are offered in substantiation of their theory. The increase in additive concentration in the oil after extended running can be explained by the partial desorption from the engine surfaces or by accumulation in the oil of film-covered wear particles. *(Abstractor: Edward H. Loeser)*

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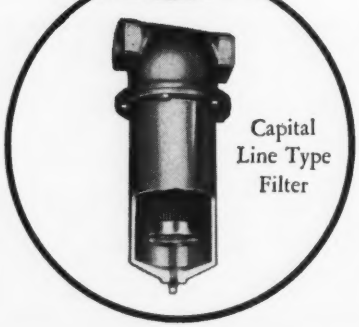

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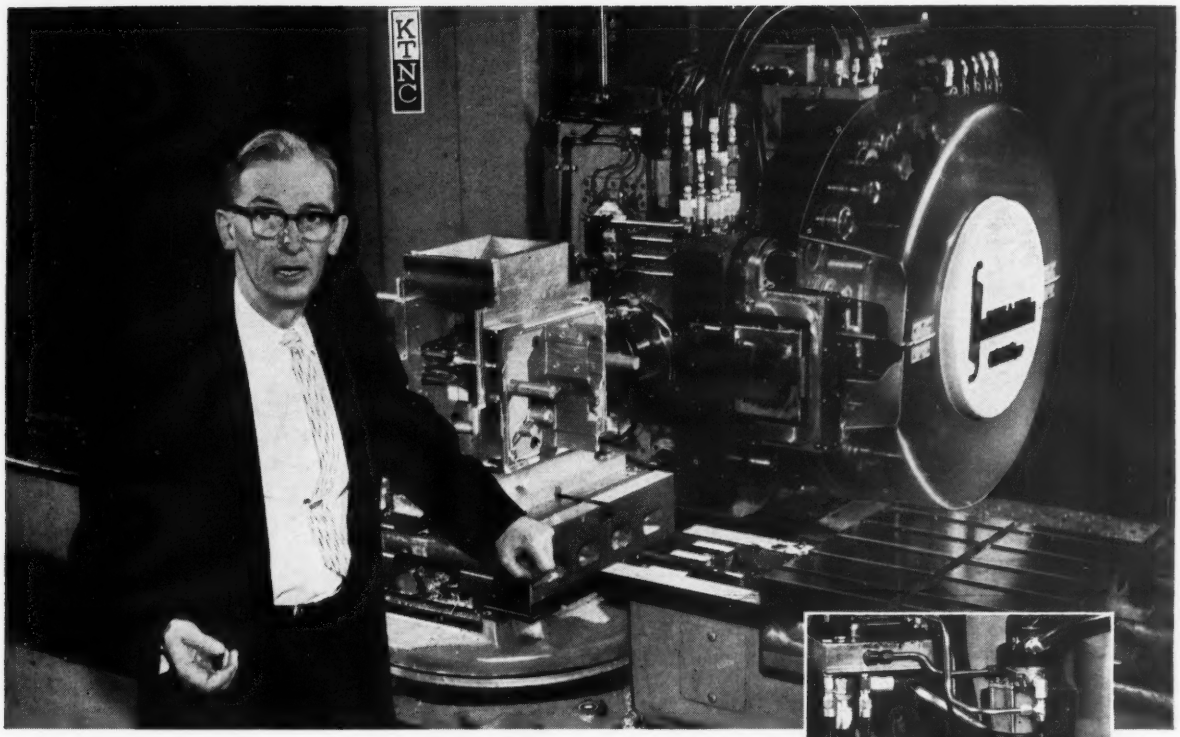

Mr. Julian Kerlin, Field Service Engineer for Kearney-Trecker Service Division, explains the contribution of Micro-Fog Lubrication to MILWAUKEE-MATIC reliability and ease of servicing.

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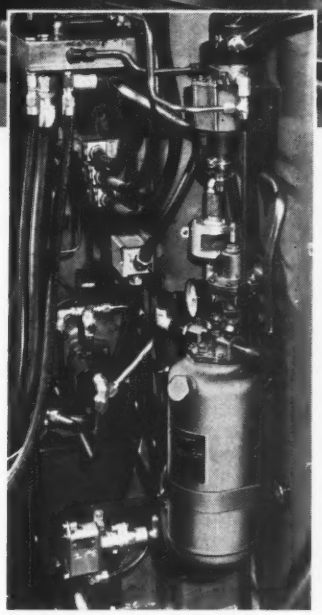

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Patent Abstracts

Compiled by Ann Burchick
Aluminum Co. of America

Oil-Soluble Carbonated Metallo Alkylated Aryl Sulfonates and Compositions Containing the Same, Patent No. 2,916,451 (H. W. Faust, assignor to Monsanto Chemical Co.) A composition comprising a mineral oil fraction having in admixture therewith 0.1-40% by weight of an oil-soluble phosphorized- and sulfurized-dicyclic terpene, obtained by reacting substantially one mol of a phosphorous sulfide with substantially four mols of a dicyclic terpene at 100-160 C., and 0.1-40% by weight of the oil soluble reaction product obtained by reacting substantially one molecular proportion of carbon dioxide with substantially two molecular proportions of a basic barium salt of a long chain alkyl substituted benzenoid hydrocarbon sulfonic acid in which the long chain alkyl substituents do not exceed a total of 4.

Polypropylene Grease, Patent No. 2,917,458 (A. J. Morway, C. W. Seelbach and S. B. Lippincott, assignors to Esso Research & Engineering Co.) A grease composition having a penetration above 290 at 77 F. and a dropping point above 500 F. comprising an oil soluble amorphous poly-propylene having a molecular weight in the range of 300 to 10,000 and an intrinsic viscosity up to 0.4, 2 to 5 wt. percent of an isotactic polypropylene having a molecular weight in the range of 100,000 to 1,000,000 and a melting point in the range of 250 to 410 F., and 5 to 35 wt. percent of a soap-salt thickener and wherein the amount of said amorphous polypropylene is sufficient to disperse said isotactic polypropylene.

Lubricating Oil Composition, Patent No. 2,921,901)R. E. Karll, A. R. Sabol and E. E. Richardson, assignors to Standard Oil Co.) A lubricant composition having improved detergency properties and suitable for use in an internal combustion engine operating on a high sulfur fuel, said lubricating composition comprising a major proportion of a lubricating oil and in combination therewith an amount within the range of from about 0.001 to about 10% sufficient to impart detergency of a neutralized phosphorus and sulfur-containing reaction product of a phosphorus sulfide and a butene polymer obtained by reacting a phosphorus sulfide with a butene polymer and subsequently neutralizing the reaction product with a basic reagent containing a metal constituent, and from about 0.01% to about 2% of a compound prepared by reacting a basic metal compound and a monohydroxyl compound selected from the group consisting of alkyl alcohols having from about 8 to about 20 carbon atoms and alkyl phenols having from about 12 to about 26 carbon atoms and contacting said reaction product with carbon dioxide at a temperature of from about zero degrees F. to about 300 F.

Manufacture of Sodium Base Grease, Patent No. 2,916,453 (R. F. Nelson, assignor to Texaco Inc.) The method of preparing a lubricating grease which comprises providing a mixture of a mineral lubricating oil and saponifiable material having an iodine number below about 80, consisting essentially of higher fatty acid and higher fatty acid glyceride and wherein the free fatty acid content is about 40-80 percent by weight, heating the said mixture in the presence of air at a temperature in about the range 300-700 F. until the viscosity has increased by about 5-35 seconds S.U. at 210 F., saponifying the said mixture with sodium hydroxide at a temperature within about the range 170-250 F., heating the saponified mass at about 250-350 F. for a sufficient period to substantially dehydrate it, and thereafter reducing the heat and adding additional mineral lubricsating oil as the mass is allowed to cool gradually.

Lubricating Compositions Containing Mixed Salts, Patent No. 2,923,682 (A. J. Morway, assignor to Esso Research & Engineering Co.) A lubricating composition comprising from 59 to 98 wt. percent of a lubricating oil having a viscosity in the range of 60 to 2500 S.S.U. at 100 F., and from 2 to 50 wt. percent of a thickener comprising a co-neutralized mixture of alkaline earth metal salts of acetic acid, intermediate molecular weight monocarboxylic acids having from 8 to 12 carbon atoms per molecule and a dialkyl dithiophosphoric acid having from 3 to 8 carbon atoms per alkyl group, the mole ratio of dithiophosphoric acid to intermediate molecular weight monocarboxylic acid being about 1:1 to 1:4, the mole ratio of dithiophosphoric acid and intermediate molecular weight monocarboxylic acids combined to acetic acid being in the range of from 1:2 to 1:15, said mixture being prepared at a temperature of about 150 to 350 F.

(Continued on page 436)

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PATENT ABSTRACTS

(Continued from page 432)

Process for Decolorizing a Hydrocarbon Oil Using an Alumina Absorbent, Patent No. 2,926,135 (W. F. Engel and P. Krijger, assignors to Shell Development Co.) A process of decolorizing a hydrocarbon oil comprising contacting said oil with particles of an absorbent prepared by adding to an uncalcined, non-activated alumina containing water of hydration and consisting essentially of particles of from 0.25 to 5 mm., an aqueous solution of an aluminum salt in an amount sufficient to substantially fill the pores of the alumina particles with aluminum salt without causing said particles to remain agglomerated on agitation, and heating the particles to a temperature above 200 C.

Forging Paste, Patent No. 2,926,138 (A. P. Huet) A forging paste adapted to be applied to a forging tool to facilitate its action upon a metal being forged which consists essentially of substantially equal parts by volume of glass in the form of very fine spherical particles, graphite, and a fluid forging lubricant selected from the group consisting of a forging oil and a forging grease.

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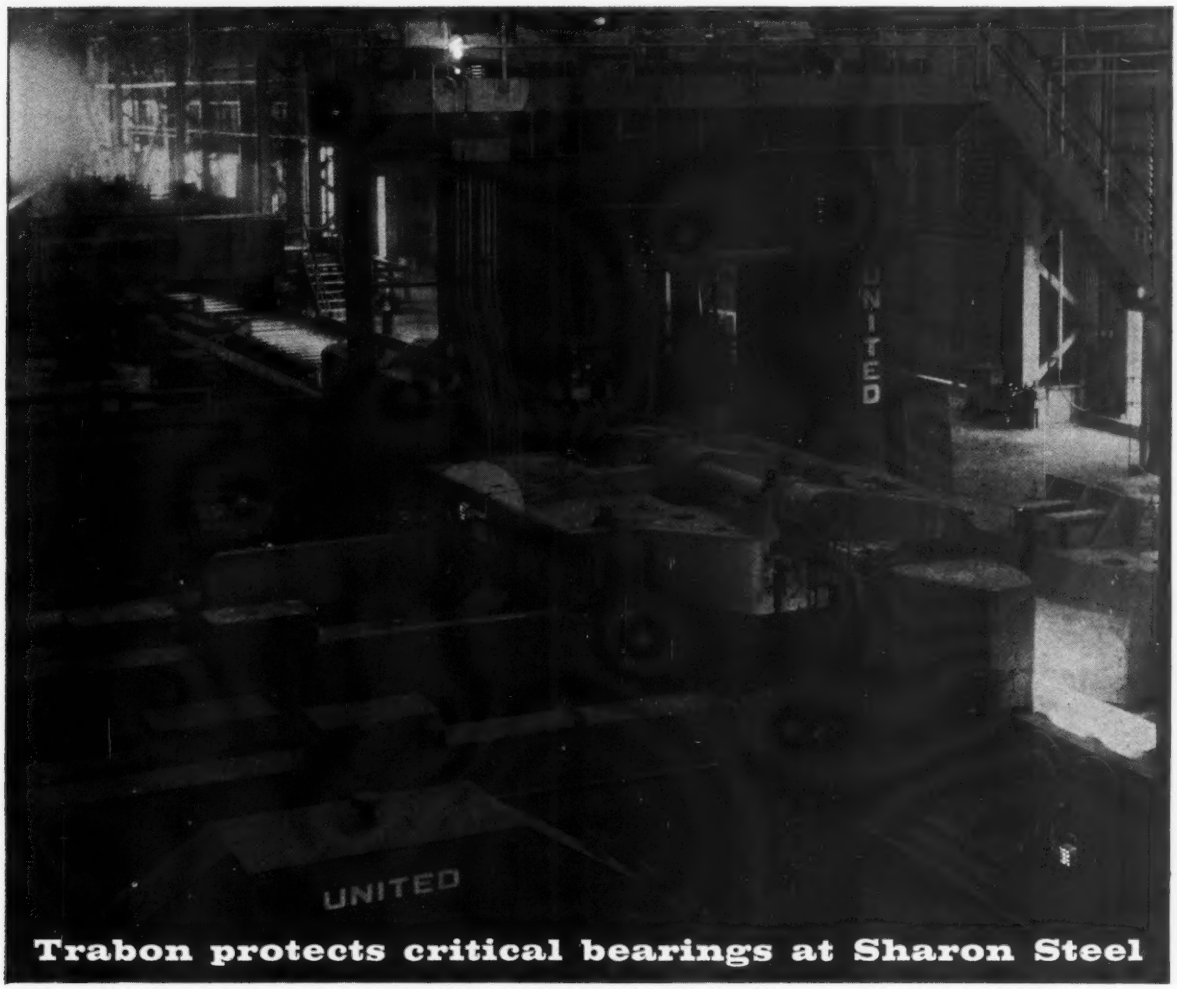

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